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Engineering Management Optimization of Machines, Equipments and Human resources of Arab- Potash Company LTD.

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Abstract

In plant operations, benefits arise from improved plant performance, such as improved yields of valuable products, reduced energy consumption, higher processing rates, and longer times between shutdowns. This work consider as a comprehensive analysis of all factors of the potash company which contribute in reduction the excess production processes and the production cost due to: time loss, workers or employment fatigue, bad or wrong machines and equipments setting and unmanaged administration, then suggesting an optimum solution to these factors, theoretically and experimentally from engineering point of view. Aapplications of motion theories, planning and scheduling techniques and forecasting for the potash demand and human resources was investigated. Based on the results using motion study it is possible to eliminate wastage of time to about 17.35% and saving a distance to 24.58%. It is helpful to reduce fatigue and boredom of work by avoiding unnecessary movements, to have more effective utilization of material, machines and workers, and to improve the design of work place layout. The safety is equal in importance to production, accidents and loss statistics are important measures of the effectiveness of safety programs. Statistics analysis showed that APC can improve the present safety programs where in the APC safety, the annual accident frequency rate (AFR) LTA's per 200,000Man- Hour Worked, the Annual Accident Severity Rate Variation (ASR) & the Accident Frequency and Severity Indicator (FSI) were decreased with time and the relation between them and time not linear. But their decrements can be increased more.

Forecasting is a central part of any organisation; simple forecasting methods often give very good results, while complex ones can give very poor ones. The results showed that for activities planning using critical path method which requires the construction manager plan and schedule in logical sequence the many detailed act required by specifications and plan to properly build structure in shortest time at least cost with minimum confusion, from the program evaluation and review technique which is inference about the activities likelihood it shows that the probability increased as it approaches the time expected by 25% or exceeded by 79.3% and from the application of time cost trade off it reduces the project or activities overall duration time by 13.95% days with a minimum increase in the project direct cost up to 3.32% JD.

In the future it's recommended to apply motion study in all potash departments & to study the conditions of work tension such as different type of sounds and vibration caused by machine in order to prevent the fatigue which reduce the power of workers, reduction of production and affecting adversely the psychology of the worker.

الملخص

عبر تشغيل المصانع ترتفع الفائدة من خلال أداء المصانع المحسن، كما هو الحال في الإنتاجية المحسنة للمنتج القيم وتقليل استهلاك الطاقة وبمعدلات إنتاج أعلى وبتوقفات اقل.

يعتبر هذا العمل دراسة تحليلية تهدف لدراسة جميع العوامل المؤثرة على العملية الإنتاجية في شركة البوتاس العربية والتي تؤثر على الوقت والتكاليف والجهد على العاملين والمعدات ومن ثم إيجاد أفضل الحلول المثالية لهذه المؤثرات والعوامل من خلال تطبيق الطرق الهندسية النظرية والعملية.

تم العمل على تطبيق نظريات الحركة وتقنيات البرمجة والتخطيط وعلم التنبؤ للطلب على مادة البوتاس وإدارة الموارد البشرية حيث تبين من خلال دراسة وتطبيق دراسة الحركة انه من الممكن التخلص من هدر للوقت بمعدل 17.3% وتجنب ما لا يقل عن 24.58% هدر في الحركة مما يساهم في تقليل الإجهاد والملل في بيئة العمل من خلال تجنب الحركات غير الضرورية مما يؤدي إلى استخدام أفضل للمواد والمعدات والعمال وتحسين بيئة العمل. إن أهمية السلامة تماثل أهمية الإنتاج ومن خلال الإحصائيات وتطبيقها نتمكن من معرفة مدى فعالية برامج السلامة حيث يبين التحليل الإحصائي لشركة البوتاس انه من الممكن لشركة البوتاس تحسين برامج السلامة الحالية حيث أن معدل تردد الحوادث السنوي وكذلك معدل تغير شدة الحوادث السنوي ومؤشر شدة وتكرار الحوادث تشير إلى توجهها نحو النقصان مع الوقت وأن علاقتها مع الزمن ليست خطية ومتذبذبة حيث يمكن تقليلها بشكل أفضل . إن علم التنبؤ هو شيء أساسي ومركزي لأي منظمة حيث أن طرق التنبؤ البسيطة تعطي نتائج جيدة في حين طرق التنبؤ الأعقد من الممكن أن تكون نتائجها غير ممثلة بشكل مناسب.

أشارت النتائج من خلال تطبيق علم التخطيط للنشاطات عبر المسار الحرج للنشاطات والتي تحتاج إلى خطط إنشائية إدارية وبرمجة بشكل تسلسلي ومنطقي انه من الممكن الوصول إلى اقل وقت واقل التكاليف بأقل الإرباكات.

من خلال تطبيق تقنية المراجعة والتقييم للبرامج والتي تعتبر طريقة استدلالية على النشاطات المتقاربة بان الاحتمالية للحدوث تزداد بمعدل 25% أو أكثر 79.3% كلما اقتربنا من الوقت المبرمج أو تجاوزناه ومن خلال تطبيق مبدأ اختصار الوقت بالكلف بأنه من الممكن اختصار الوقت الكلي للنشاطات بمعدل 13.95% يوم وذلك بأقل زيادة للكلف المباشرة وبمعدل 3.32% بالدينار.

يوصى بالدراسات المستقبلية العمل على تطبيق دراسة الحركة على جميع مرافق شركة البوتاس العربية ودراسة العوامل الأخرى المؤثرة على بيئة العمل كاهتزاز المعدات والضوضاء والتي تساهم بتقليل الإنتاجية والتأثير على نفسية العامل والإنتاجية كخلاصة لهذه العوامل .

Chapter One:
Introduction

1.1General:

Starting from the days of Frederic W. Taylor and his contemporaries, notably H.L. Gantt and the F.W. Gilberth (1882 to 1912) [3,32], Industrial engineering has been considered a dynamic profession. In the engineering field, Industrial engineering is one of the fastest growing profession. In the beginning industrial engineering was closely associated with the time and motion study. This position continued from 1903, the year of main pioneer work of F.W. Taylor through his paper on "shop management", till 1933 when the term " method engineering" or " method study " developed by H.B. Maymard and his associates was added.

In the year 1943 [3], the work standardization committee of the management division of the American society of Mechanical, Engineering (A.S.M.E.) attempted to define the limits of the field of industrial engineering. one appealing definition described by the American institute of industrial engineers is given hereunder:

Industrial engineering is concerned with the design, improvement and installation of integrated system, of man, materials and equipments drawing upon specialized knowledge and skill in the mathematical, physical and social sciences either with principles or methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such system.

The above definition shows that the field of industrial engineering is quite broad and all the high productivity techniques are well within its purview. Industrially advanced nations have been greatly benefited by the application of the Industrial Engineering techniques in raising their productivity and consequently, their standard of living.

1.2 Industrial Engineering:

Born in the late nineteenth century, industrial engineering is a dynamic profession whose growth has been fuelled by the challenges and demands of manufacturing, government, and service organizations throughout the twentieth century. It is also a profession whose future depends not only on the ability of its practitioners to react to and facilitate operational and organizational change but, more important, on their ability to anticipate, and therefore lead, the change process itself [3,34].

The field of industrial engineering represents an area that is today undergoing rapid expansion and diversification. for example, among the

many activities that an Industrial Engineering specialist might be called upon to engage in, we find the following:

a. Locate new plants and design their physical layout.
b. Analyse and plan production schedules and inventories .
c. Devise ways to improve the productivity and moral of people at work.
d. Study equipment replacement feasibility.
e. Conduct the effective work measurement and set the time standards for effective wage payment.
f. Diagnose and correct causes of poor quality.
g. Conduct the study for methods improvement.
h. Measure the effectiveness of marketing, advertising and other distribution policies.
i. Design, develop and evaluate complex man machine systems.
j. Utilization of digital computers to receive tremendous quantities of information to digest, process and store information, and then to display this information for appropriate decision making.
k. Evolve better production methods by applying operation research techniques.

1.3 Human Resources:

The existence and continuation of any organization –whatever its size and range of activities depends on its successful utilization or managing of a variety of different' resources' available to it.

We can define "resources" as being something which helps or aids an organization to achieve its objectives or goals; those might be the manufacture or production of products, the sale of products, or the provision of services (or two or all)[31].

Human Resource Management (HRM) is the function within an organization that focuses on recruitment of, management of, and providing direction for the people who work in the organization. Human Resource Management can also be performed by line managers. Human Resource Management is the organizational function that deals with issues related to people such as compensation, hiring, performance management, organization development, safety, wellness, benefits, employee motivation, communication, administration, and training.

1.4 Project Planning:

In designing an environment for the effective performance of individuals working together in groups, the most essential task is to see that purposes and objectives, and methods of attaining them, are clearly understood. If group effort is to be effective, people must know what they are expected to accomplish. This is the function of planning. As we know that production requires the organized utilization of natural resources, men, money, material and machines. We also know that " production is an organized activity of converting raw materials into useful products [20].

Planning is the most basic of all the managerial functions. Perhaps there is no more important area of human activity than managing, for it is the basic task of all managers at all levels and in all kinds of enterprises to design and maintain an environment in which individuals, working together in groups, can accomplish pre-selected missions and objectives[4].

Management is a process concerned with the achievement of goals or objectives. Project management involves the coordination of group activity wherein the manager plans, organizes, staffs, directs, and controls to achieve an objective within constraints on time, cost, and performance of the end product. Planning is the process of preparing for the commitment of resources in the most effective fashion. Controlling is the process of making events conform to schedules by coordinating the action of all parts of the organization according to the plan established for attaining the objective. It can also be said that project management is a blend of art and science: the art of getting things done through and with people in formally organized groups; and the science of handling large amounts of data to plan and control so that project duration and cost are balanced, and excessive and disruptive demands on scarce resources are avoided. A project is a temporary endeavor undertaken to create a unique product, service, or result [1, 29].

1.5 The Art Of Management:

Management is the art of creating industrial relations, in order to secure co-operation. In this part, the scope of this art, and some of the chief difficulties inherent in it, is surveyed. The title " initiative " emphasizes the fact that the manager aims at fostering a spirit of enterprise throughout the organization under his control. He endeavors, not merely to get people to work, but to get them to work willingly, and to employ their powers of initiative, so far as is justified by their position, in contributing to the general effort.

Initiative, which is the faculty of doing something new, is the source of all industrial and commercial developments. Every enterprise owes its

origin to the initiative of some person who has perceived its latent possibilities, and who has the ability, energy, and resourcefulness to get it going. Initiative is needed in seeking new knowledge, new designs, new techniques of production, new methods of organizing work, new ways of using natural resources, or new markets. It is an essential factor in maintaining industrial activity in a healthy condition throughout changing external conditions.

The manager's own initiative in putting into practice modern ideas on management, and in endeavoring to allay mistrust and antagonism, and hence in securing true co-operation, is undoubtedly one of the main factors contributing to the improvement of industrial life [16,32].

1.6 Objectives Of The Present Work:

It is a comprehensive analysis of all factors of the potash company which contribute in reduction the excess production processes and the production cost due to : time loss, workers or employment fatigue, bad or wrong machines and equipments setting, materials storage, and unmanaged administration.

Then suggesting an optimum solution to these factors, theoretically and experimentally from engineering point of view. This work will study and analysis in details all production lines and departments such as power plant, maintenance training center, shipping trucking …etc.

The human resources, policy, strategy and management, communication, manpower planning, training and employee development also will be analyzed during this work .

The application of industrial engineering management and management science through the analysis will include the following items:-

1. Work and productivity.
2. Motion study.
3. Time (work measurement.
4. Machine interference.
5. Plant layout.
6. Types of production.
7. Materials handling.
8. Inspection:- which will be carried out for conforming that quality is of predetermined standard.
9. Case planning and scheduling will include:
   Gantt charts.
   C.P.M (Critical path method.

P.E.R.T.(Programmed Evaluation and Review Technique) is a technique used for scheduling and controlling the projects.

10. Materials management and inventory control.

1.7 The Importance Of The Present Work:

The following benefits will be achieved from this work:

1. Reveals the strong relationship between industry and the theoretical analysis.
2. Encourage the engineers to apply their academic study on practical and industrial situations.
3. To give positive idea to all employers (workers) that how can get advantages if they apply the works and researches of universities in their work (for example, in industry cost, improving production, demand forecasting, planning and scheduling, and industrial safety.
4. Also give the researches a practical experience to link the theoretical science with the practical field.

   So in this work, the well known industrial company, which is the Arab Potash Company was chosen as a case study to apply the engineering management science to raise the company productivity and to improve its income.

Chapter two:
Literature Review

2.1 Introduction:

During the Dark Ages after the fall of the Roman Empire, there was little science or art in Western Europe. Strangely enough, the Arabs inherited Greek and Hindu science, and developed the system of numbers and also the rudiments of algebra which are the basis of present- day mathematics. The Renaissance in Europe, beginning in the fifteenth and sixteenth centuries, saw a reawakening of interest in Greeks, Roman, and the Arab thought, and also the emergence of new thought, science and philosophy.

Leonardo daVinci(1452- 1519)[9,32], besides being famous as an artist, was one of the greatest of scientists. His theories were founded on a very wide and practical knowledge of the of the applied arts of his day. His note –books contain descriptions and sketches of an amazing variety of mechanical appliances, mechanisms, gears, pulleys, levers, machines for planning, filling, polishing, grinding, turning, screw cutting, wiredrawing, screw propellers, pumps, irrigation and drainage schemes, cannons. Leonardo understood the principles of inertia, momentum, action and reaction, inclined planes, the strength of pillars, friction, the conservation of energy, and he restated the theories of Aristotle, Archimedes, and Euclid on static's. Unfortunately, Leonardo's note-books lay hidden for centuries, so that his influence was limited to his immediate pupils.

The seventeenth century has been called the " century of science". Copernicus (1473- 1543)[9] had shattered the Aristotelian theories on astronomy, and so paved the way for a new study of nature. Kepler (1571- 1630), Stevinus of Bruges (1548- 1620), Galileo (1564- 1642), Newton (1642- 1727), Robert Hooke (1635- 1703), Huygens, Descartes, Leibnitz, Torricelli, Mariotte, and Pascal, laid the foundations [30].

During the seventeenth century, it was still possible for any scientist to aim at acquiring all knowledge, of all sciences. Interest of science was awakening all over Western Europe, partly as a result of the invention of printing and dissemination of ideas in printed books. In spite of wars, men of science were able to communicate with each other and to travel unhindered.

2.2(1750- 1850)Establishment Of Engineering:

This period, the Industrial Revolution, saw the real beginning of engineering, the invention of the steam engine, the development of metallurgy, and of machine tools. Heron of Alexandria had constructed a steam turbine 2000 years previously, but it was looked on as a toy, and the very possibility of harnessing heat as a source of energy was unknown, until Huygens in Holland in 1680 attempted to use gunpowder to drive an internal – combustion engine. In 1690 Papin invented the cylinder and piston. In 1705 Newcomen invented the first steam engine, incorporating a cylinder and piston. James watt, instrument maker to Glasgow University, was repairing a model of a Newcomen engine, and was struck by the enormous consumption of steam. His efforts in this respect represent one of the earliest truly scientific efforts at dealing with an engineering problem.

Triple- expansion engines came into general use for marine propulsion about 1870-80, and high- speed reciprocating engines for generating electricity about 1900 [32].

In 1781 Court developed the coal – fired pudding process of manufacturing wrought iron, and methods of rolling it. In 1828 Neilson of Lanarkshire introduced the hot blast in the production of big iron, using regenerative ovens and cutting down the quantity of fuel needed by more than half. In 1856 Bessemer devised his method of removing carbon, silicon, and other impurities from iron by blowing air through the molten iron. Thomas and Gilchrist in 1879 found that the use of basic lining to the Bessemer converter enabled phosphoric ores to be reduced, an invention which lead to great developments in the German iron industry. Wm. Armstrong in 1850 invented the hydraulic accumulator system, which enables a store of water to be kept at high pressure.

2.3 Nineteenth- Century Engineering Science:

The practical achievement of the engineers of the Industrial Revolution stimulated interest in the scientific understanding of these new machines. At the same time it was becoming recognized that pure science, hitherto studied largely for its own sake, had a valuable contribution to make to engineering.

Newton's laws of motion remained the foundation stone of machines, though there was still some confusion due to lack of agreement about the definitions of quantities such as power, motion, and energy. Watt introduced the idea of "horse-power" and defined it is equal to 33,000 foot-pounds of work per minute. The science of chemistry was founded on a solid basis by the work of John Dalton (1766-1844), who enunciated the atomic theory,

and classified 25 elements. This followed the work of Lavoisier, who in 1774 showed the true nature of combustion, destroying the widely held theory that in combustion the burning fuel gave off hot substances called phlogiston which had a negative weight. The true nature of gases was beginning to be realized, also the fact that the gaseous state was one of the normal state of any substance. Henry Cavendish discovered hydrogen gas in 1766. Air was recognized to be a mixture of oxygen and nitrogen. Avogadro in 1811 state his law that equal volumes of all gases under the same conditions contain the same number of " molecules", defining the molecule as the smallest amount of a substance that is in free existence under normal conditions. Sadi Carnot (1796-1832) was the first to study the theory of the heat engine and its possible efficiency [9,32]. In 1824 he showed that such an engine should receive its heat at the highest possible temperature and reject it at the lowest possible temperature. Clausius (1822-88) in 1850 stated the second law of thermodynamics, that heat cannot of itself go from a cold body to a hot one. Kelvin in 1848 evolved his absolute scale of temperature, based on equal increments of temperature producing equal amounts of work. Rankine devised a theoretical cycle of operations for the steam engine, with which actual engines could be compared. From this time onwards the whole science of thermodynamics was developed by the work of many investigators.

Another new science of direct importance to engineers was the science of elasticity and strength of materials. Galileo had studied the resistance to rupture of a cantilever, but had not reached any useful results. Hooke's law of proportionality of extension to load, enunciated in 1678, was the basis of subsequent theory. Thomas Young (1773-1829) developed Hooke's theory and gave his name to the relation of stress to strain, or Young's modulus of elasticity. Poisson (1781-1840) studied the relationship of extension and rigidity [32].

Another new science, which by the end of the nineteenth century was beginning to have its influence on engineering, was the science of electricity. Benjamin Franklin (1706- 90) had shown the existence of electricity, and Ampere showed the relationship between the electricity and magnetism. Henry Cavendish (1731-1810), Coulomb (1736- 1806), Galvani (1737-98), and Volta (1745-1827) added to knowledge. Faraday (1791-1867) investigated electromagnetic induction and laid the foundations for the invention of the electric dynamo and motor. Clerk Maxwell showed theoretically the relation of heat, light and electricity. Helmholtz in 1847 propounded the law of conservation of energy. Edison and Swan independently invented the electric light bulb. Progress in engineering

science was greatly facilitated by the advances in the art of measurement which followed the work of Joseph Whitworth, who about 1840 developed his true plane gauges and measuring machines. The general use of accurate measuring instruments followed the introduction of micrometers by brown and Sharp and Starrett in America, and Johansson's slip gauges in Sweden.
As an instrument for measuring areas, a Bavarian engineer, J.H. Hermann, invented the planimeter in 1814, but not till Jacob Amsler in 1845 invented his much simpler and cheaper instrument, of which he sold 12,000in 30 years, was the planimeter much used. In 1887 Captain Prytz invented the hatchet planimeter which was introduced and popularized in England by Professor Goodman. Amsler invented other integrators. Lord Kelvin invented a harmonic analyser in 1875 and used it for the harmonic analysis of tidal observations [30].

2.4 Personnel Management In Transition:

For almost two decades analysis of the employment relationship has focused on the many uncertainties surrounding the emergence and consequences of human resources management (HRM) as involving particular strategies and approaches towards the management of labour, with analysis centring on the breadth and scope of HR policy.

At the end of the 1980s there was general recognition that competitive pressures were forcing employers to review personnel practice, but there were only the beginnings of a debate about whether personnel management was in transition and, if so, where it was going. By the mid 1990s, fundamental changes were afoot, but there were major questions about the degree to which these changes marked a fundamental break with past practice in the direction of the emerging HRM models. By the end of 1990s, it became clearer that there had been a major reshaping of HR practice in the UK, but many employers appeared to be following the low road of cost minimization associated with low pay, disposal labour and outsourcing rather than the high road of skill development, partnership and mutual gains. In terms of the debate about the definition of HRM it is striking that in comparison to a decade ago much of the controversy has dissipated. When HRM emerged in the late 1980s and 1990s it was the definition of HRM as a specific, high commitment style of HR management, signalling' a radically different philosophy and approach to the management of people at work' that proved controversial. This normative approach to what manager' should do' was criticized because it did not reflect actual developments in many workplaces. Increasingly, however, a broader, more encompassing definition

of HRM has gained ground that downplays many of the preoccupations of HRM of the 1980s and 1990s [2].

HRM can usefully be defined in a generic sense as an approach that uses a variety of policies and practices related to the management of people, but it differs from employee relations in its dominant interest in management practice which tends to ignore employee interests.

HRM assumes that the interests of employees and employers will coincide and is preoccupied with the end goal of organizational effectiveness that marginalizes the interests of other stakeholders such as employees. HRM is also predominantly focused on the individual firm and seeks solutions to HR problems within the firm, with analytical focus on the motivations and aspirations of individual employees. This largely precludes the possibility that HR problems may lie beyond the boundaries of the firm and that employees may wish to combine together and act collectively to further their own interests.

2.5 The Evolution Of HRM Origins:

The term 'human resource management' crossed the Atlantic in the 1980s and the UK debate has been shaped in large part by its US heritage. The antecedents of HRM originated in the study of large non-unionized US companies such as IBM and Hewlett-Packard. In these companies HRM has been associated with a particular style of people management that placed a great deal emphasis on gaining the commitment of individual employees to organizational goal. In this unitarist perspective, management is viewed as the sole source of authority that safeguards the interests of managers and workers; trade unions are regarded as interfering unnecessarily in the harmonious relationship between employees and managers. UK employers and policy makers were receptive to this unitarist perspective in the 1980s and the resonance of HRM can therefore be linked to the political and economic context and the dominant ideological values prevailing at this time. In particular, intensified competition made the task of effective personnel management more urgent. Related pressure in the public sector arising from policies of privatization and market testing presented similar challenges as public sector managers were encouraged to emulate private sector ' best practice'. The popularity of the term ' HRM' came to symbolize not only a belief that major changes in product markets required a fresh management approach, but also that Conservative government reforms of the labour market allowed managers to exercise an unprecedented degree of ' strategic choice' in shaping organizational employment practices. With trade unionism in retreat, employers had an opportunity to decide whether to

(de)recognize trade unions and to develop a more direct relationship with the workforce with the establishment of new channels of participation and involvement [2].

2.6 The Development Of Scientific Management:

In order to gain a fuller understanding of modern ideas on management, it will be useful to trace the development of the art of management, and of the application of scientific method to management problems. There has, of course, been management of industrial activity since the beginning of history, but generally speaking, it has been of a fairly elementary order. The need for better methods arose during the time of Industrial Revolution, when organizations based on the deviation of labour and trade were being established. As such organizations have increased on number, size, and complexity down to the present day, so has the art of management involved greater skill and knowledge. The essence of scientific management lies in the adoption of methodical processes of observation, recording, analysis, comparison, hypothesis, and generalization tested by experiment.

These processes place the manager in the position to select the best methods out of alternatives offered, of building up an efficient organization, and of creating a sound financial basis for an enterprise.

Many of the enterprising individuals who were responsible for the industrial growth of the eighteenth century showed these abilities to a marked degree. The example chosen to illustrate genius in the scientific analysis of management problems is that of John Loudon McAdam (1756-1836), the maker of roads. Macadam's name is popularly associated with the method of making roads by the use of stones broken to a uniform size and crushed together by the passage of wheels, known as macadamizing . McAdam's true genius, however, is seldom appreciated, although his work was probably the first great example of scientific management. Not only did he utilize his scientific abilities as a manager to develop the technique of road making, which is really an engineering problem, but he studied and evolved methods of organising the work, and of establishing the finances and public of roads on a sound basis [9].

Adam Smith studied the division of labour and pointed out the conditions under which its advantages could be secured. Ark Wright developed factory organization and discipline, Robert Owen devoted his energies to improving the welfare of his employees, Telford showed how to create vast organizations for carrying out civil engineering work. The books written about the mid-eighteenth century by Samuel Smiles on the lives of

the Engineers and Kindred subjects created for the great public interest which was shown in the work of these pioneers.

The first suggestion that the principles of the scientific method were applicable, and ought to be applied as a matter of course to all management problems, came from the writings of Charles Babbage, a Cambridge mathematician. Babbage endeavoured to define the principles upon which the industrialist, applying sound economic theory and the latest technical improvements, should organize production so as to secure the maximum efficiency and stability. He was indeed trying to outline a science of management, intermediate between the sciences of technology on the one hand and of economics of the other.

2.7F. W. Taylor (1856- 1915):

During the nineteenth century, progress towards specialization was being made on the continent and in U.S.A., though as yet British industry was far ahead of any other. By the beginning of the twentieth century, however, industrial production was developing so rapidly in U.S.A., making the problem of management so important, that the next great steps towards management philosophy came from that country, as they have continued to do ever since. Management of industry was notoriously bad. There was a general spirit of antagonism, suspicion, and enmity between employers and employees. Output was low, due to what Americans called " soldiering ", or what we call " ca' canny ", or " go easy". Soldiering was both natural, the men being as lazy as they dare be, and systematic, proceeding from some intricate reasoning and second thoughts. It was encouraged by rate –cutting. Throughout American industry, the management's idea of a proper day's work was what a foreman could drive his men to do. The worker's idea of a day's work how little he could do. As a result, there was a vicious circle of low wages, low production, and low purchasing power, leading to dissatisfaction, strikes, and unrest.

Taylor, from 1884-6[3], was manager of the machine shop of the Midvale Steel Company, a concern making and machining heavy forgings for guns and railway wheels.

Taylor found that many of the men were inefficient from lack of understanding of their craft. He found the management inefficient, and the planning of the work poor, leading to much waste of time and effort. The soldiering was the worst evil. Even skilled men spent much of their energy in thinking out ways of cheating the management.

Some attempts had been made to cure the evil by introducing premium bonus schemes, but without much success. Taylor declared that the

trouble lay in the management, and that incentive schemes were no substitute for efficient management. He said that a manager should know, by how much work a man should do in a day on any operation, how to train the man to do this amount, and also how to calculate scientifically the correct incentive to be offered to him. Good management should give satisfaction and prosperity to both employer and employee. It should promote co-operation instead of antagonism.

Taylor believed that the time required for a job was something capable of scientific measurement and not a subject for argument and bargaining.

Taylor looked on the manager as the finder and interpreter of the laws, not as its maker. It was the manager's job to obtain the law, then to teach it to the men, so that they could work in the best way and earn the bonuses offered.

2.8 Henri Fayol (1841- 1925):

At the same time that Taylor was carrying out his investigations into the technical problems of production and works organization, Henri Fayol in France was studying the administrative side of business undertakings. He was a practical man, who in the course of sixty- five years' connection with the firm of commentary, four of sixty- five years' connection with the firm of commentary, Four-chambault and Decazeville brought it from the verge of bank- ruptcy to prosperity.

Fayol dealt with the structure of an industrial undertaking as a whole, bringing out the idea of management as being one of the " functions" of industry. He divided this function into six component functions: technical, commercial, financial, security, accounting, and administrative. He held that management involved six main activities, namely: forecasting, planning, organizing, commanding, co-ordinating, and controlling [32].

2.9 Mary Follett (1868- 1933):

One of the most essential qualifications for management is an understanding of the psychology of industrial relations, and of the mechanism whereby the activities of the members of an organization are directed and controlled. Mary Follett studied these aspects of industrial and business administration in America, Great Britain, and elsewhere. Many false ideas were, and still are, current on these matters, and are the source of much industrial unrest. Marry Follett applied the principle of " integration of view points " to the problems of determination of policy, control, discipline, employee representation in management, conciliation and arbitration, and leadership. She emphasize that conflict of opinion ought to

lead, not to antagonism, but through conference to the evolution of new ideas, resulting in new progress. The basic theorems which she enunciated apply not only to industrial relations, but human relations of any kind, including those of government and international co-operation. She studied these other subjects too, but it was amongst business men, she said, that she found the greatest vitality of thinking to –day and the most active pioneer work in organization human effort [33].

2.10 The Fourth Industrial Revolution:

The fourth industrial revolution based on oil, the automobile and mass production, taking place between 1900–1950 and onward, and the fifth phase was based on information and telecommunications and the post-war boom from 1950. These waves of innovation and industrial development have become known as Contractive waves, K-waves, long waves, super cycles or surges, and relate to cycles in the world economy of around fifty years duration consisting of alternating periods of high and low sect oral growth. Paradigm of five waves of innovation since the first Industrial. Revolution, although the precise dates, phases, causes and effects of these major changes are hotly debated, as is the nature of the sixth wave based on new knowledge production and application in such fields as IT, biotechnology and materials beginning around 1980, and the possible seventh wave based on sustainable 'green' engineering and technology seen to have begun around 2005.

2.11Today's Industrial Engineer:

The industrial engineering profession is perhaps more diverse that any of the other engineering disciplines. Among us you will find engineers working in facilities design, work methods, simulation, human factors, production planning, operations research, information systems, and many other areas. The Bureau of Labour Statistic's Online Occupation Outlook Handbook indicates that there were approximately 115,000 practicing industrial engineers in 1994 [31]. Of these more than 75 percent were employed in the manufacturing sector with the remaining employed in utilities, trade, finance services, and government. The discipline is expected to grow by 10 to 20 percent per year through the year 2005. This means that there will be between 328,000 and 854,000 industrial engineers at that time. By the year 2020, when most of the advancements discussed will be realized, a 20 –year-old industrial engineer (or student) in 2000 will be 40 years old. Because of the high percentage of industrial engineers in the manufacturing sector, it is likely that the outlook for industrial engineering

will be highly correlated with the future of manufacturing. In general, most industrial engineers are concerned with the design and integration of system components such as people, equipment, facilities, and methods to create and improve efficient and effective systems that produce goods and services beneficial to humankind. Engineering is the application of science to model, analyze, and solve problems.

The standard sciences of the industrial engineers are mathematical, statistical, and computer sciences. Common modelling and analysis techniques include optimization, stochastic process simulation, economic analysis, production planning, forecasting, job analysis, and facilities design. The diversity of the discipline requires that the industrial engineer be adapt at locating information and collecting model design and input information. Computer technology and tools facilities our modelling and analysis, providing us with a means of visualization and rapid computation. Communication technology and tools facilitate information collection and dissemination. These are the technology advancements.

2.12 Information Technology:

Computing performance for some time now semiconductor price performance has doubled about every 18 months. This phenomenon is called Moore's law .And while there has been some healthy scepticism that this phenomenal growth can continue at this pace; there is no evidence of a slowdown. Projections of information technology and performance to and beyond the year 2010 are shown in table [2.1].

In late 1999, 500-MHz processors were projected to be in a majority of the more than 90 million personal computers that will be sold. IBM is currently conducting research into quantum computing at room temperature [34]. It is projected that this technology could be commercialized as early as within 10 years, increasing computing speed up to 1600 times that of present day CPUs (central processing unit. The world's fastest supercomputer developed under the Accelerated Strategic Computing Initiative program by the U.S. Department of Energy in cooperation with Sandia National Laboratories [34]operates at over 1TFLOPS (tera floating operations per second. The Japanese government's 1997 technology forecast predicted memory capacity of 1 Tbit per chip by 2013 and VLSI (very large scale integration) with as much memory as 256 Gbits per chip by 2014. For the industrial engineer, these advancements in computation will significantly impact the time required for conducting optimization and simulation analysis.

Table [2.1] Projections of future information Technology

Technology	Toward year 2005	Toward year 2010 and beyond
Computing technology	1999:500-MHz microprocessors	2008:10Tflop supercomputers
	2000:1000-MHz workstations	2009:1 million processor parallel computer
	2005:1000- 2000MHz microprocessors	2010:64-1600increase in microprocessor performance
	2000:128-Mbit stamp- size memory cards	2013:1Tbit memory chips
	2001: widespread use of 400 – Gbit 1-inch platters	2014:VLSI 256-Gbit chips
		2017:100-Gbit erasable RAM
		2018:1-TIPS microprocessors
		2018:10,000 cell bio circuits
Internet Technology	2000:327 million Internet users	2009: affordable 150 Mbit connections
	2001:affordable 10 –Mbit modems	2009:household optical fiber
	2002:1-Tbit fiber – optic speeds	2010:1-2 billion Internet users
	2002:$ 1.2 trillion Internet economy	
	2005: on – demand global multimedia	
Wireless technology	1998:2-Mbit wireless LANs	2010:radio waves offer millions of simultaneous
	1999:worldwide access voice communication	Local connections over 100 Mbps
	2000:64-Kbps Internet with satellites	2011:widespread 100 Mbps global access

2.13 Simulation Technology:

One outcome of the dramatic advances in information technology will be in the area of computer simulation. Computer simulation has long been an important tool used by industrial engineers to solve a variety of problems. Several predominate; discrete event simulation languages used today were developed in the industrial engineering community. However, many relatively complex and fascinating simulation systems have been developed

for the entertainment industry in the form of games. One such game is designed to simulate cities.

At a machine level it might be desirable to create a process simulation for control and machine monitoring. Another level might be the product flow level for analyzing scheduling and inventory polices. A higher level could be an enterprise simulation for analyzing information flow and strategic policy making. Simulation is an attempt to capture a portion of the real world in a computer. With advances in computation and communication technologies, we are approaching an ability to perform computer experimentation on multilevel complexity systems [5].

Some of the major application areas for simulation include communication systems, dynamic systems, electric power systems, military systems, environments and ecosystems, and discrete parts manufacturing.

Over the past tow decades there has been a phenomenal growth in the research and development of object –oriented simulation (OOS) tools and techniques. General –purposes OOS languages typically have class libraries available for the simulation engine and facilitates for building other classes. OOS can be built using general –purpose object –oriented (OO) languages such as C++, JAVA, which do not typically come with standard simulation class libraries.

The fundamental characteristics of OOS make it particularly well suited for larger, more complex, distributed simulation, and Internet –based simulation. Many of these new environments will be commercial, but an even greater number of the simulation environments developed will be owned by individual organizations [6].

2.14 Educational System:

Education in modern Europe is viewed in connection with the diversity of society, economic and social rights of individuals, human rights, equity and gender equality. Education processes are not perceived unambiguously either. Today education is not only teaching and learning; it includes also lifelong learning, mobility integration, further education, self-evaluation and other areas. Ministers of education of European countries have agreed on three major goals to be achieved by 2010 for the benefit of the population and the European Union (EU) as a whole:

(i. To improve the quality and effectiveness of EU education and training systems;

(ii. To ensure that they are accessible to all.

(iii. To open up education and training to the wider world.

When implementing a national programmed Development and Implementation of a Lifelong Learning Strategy aimed at the development of lifelong learning, a uniform state strategy for lifelong learning and its implementation programmed will be developed; organizational, informative and educational support for the development of lifelong education programmed in regions will also be provided. The national programmed will ensure the creation of a uniform conceptual approach to lifelong learning thus helping each region individually and the state as a whole to gather information on the existing education resources and to define the necessary development trends. In order to reduce social and economic disparities, the programmed will ensure education planning in compliance with regional economic development plans. Regions will have a possibility to get the necessary support for human resources development. Focus will be on developing civic, educated and economically active society which, in its turn, will ensure the increase of the population's welfare level.

Factors influencing the development of these processes have to be taken into account when implementing education policy planning initiatives and activities. Regarding the priorities set out in the programmed Education and Training 2010, the following factors hinder to fully develop national education and training policy fields:

1. The labor market demand is insufficiently harmonized with the education supply.
2. Insufficient resources for renewal and upgrading of the material and technical basis of education institutions.
3. Insufficient financial resources for the creation of new study places in the thematic fields of science and mathematics, as well as engineering and technology education.
4. Negative features regarding the number and age structure of academic staff.
5. Insufficient international mobility of students and university lecturers;
6. The slow pace of the state territorial and administrative reform which hampers designing of regional development plans and planning of human resources.
7. Insufficient cooperation between professional education institutions and employers. In order to promote participation of local governments and employers, international comparability of vocational education programmed has been enhanced; competitiveness of labor force has increased in the local and foreign labor market. A uniform assessment of educates' learning results has been ensured, a uniform procedure for

centralized professional qualification examinations has been introduced in the systems of primary vocational and further vocational education.

In the context of lifelong learning, the normative and legislative basis has been put in place with regard to the fields of general, vocational and higher education. An optimal network of all level and type education establishments and education support institutions exists in the country. Education system democratization and decentralization took place from 1990 to 1994. From 1995 to 2001 special attention was paid to putting in place the education system by substantially supplementing the normative and legislative basis. The Law on Higher Education Institutions created a principally new legal basis for functioning of higher education institutions and established autonomy of higher education establishments for the implementation of higher education. In 1997 integration of research institutes into higher education establishments started in order to ensure the development of quality study programmed.

In order to obtain credible and safe data for the analysis and development of the education policy, a unified education quality assessment system has been introduced in the country in 2005. This system provides the use of the same criteria both for the school work self-evaluation and external evaluation [15].

2.15 The Arab Potash Company:

Arab Potash Company (APC) was formed to develop the minerals of the Dead Sea. In doing so APC has been successful in achieving profits for the shareholders and assisting in developing the local community. Currently APC and its Subsidiaries are producing Potash for Agriculture, Industrial Potash for the chemical industry, Industrial Salt, Bromine and NPK fertilizers. APC considered one of the most pilot regional companies in production of Potassium Chloride "KCl" which is a useful in Fertilizers industry. The idea of the Potash project was based on the Potash Plant located on the north-western shores of the Dead Sea during the British Mandate. The old plant was destroyed but the idea remained alive and a Pan Arab company was formed in 1956 to implement a project for the production of Potash using the minerals of the Dead Sea. The site is located 110kilometers south of Amman and 200kilometers north of Aqaba. The site is a Solar Evaporation Pond System of an area of 150 square kilometers and processing plants for the ore. The investment in the original project, including substantial infrastructure was nearly 480 Million JD. Financing was obtained through loans from international finance institutions and aid agencies as well as Arab development funds. The project began in 1976 with

tests and experiments to determine the parameters of various technologies and ideas in a very hostile environment. Construction began in 1979 and was completed in 1982[13]. At the end of construction, about (117) kilometers of seepage proof dykes were built (other dykes built later on. These were more than 8meters wide at the top and were an engineering challenge to be built on top of a non- stable sea bed. The excavation carried out during the construction period was of a colossal magnitude, 16 million cubic meters of earth material was displaced.

Potash production began in 1983 and has since progressed with various schemes aimed at optimizing and expanding this production. The initial plant was built to a capacity of 1.2 million tons of product. This was expanded in the late eighties to handle 1.4 million ton and key modifications were undertaken with the Solar System to enhance the production of the ore accordingly. A second plant based on different technology and of a capacity of 0.4 million tons was built in 1994 and this brought the total production capacity to 1.8 million tones. The cost of the new plant was around 120 million JD. There are plans to expand through further optimization of the existing plants. Projects are underway to expand the Solar Evaporation System and construct another plant and thus raise the capacity to 2.4 million tons of product after the year 2008 [13, 14]. The capital of the Arab Potash Company is 83.318 million JD. It has a concession from the Jordanian Government to exploit, manufacture, and market the mineral resources of the Dead Sea, until 2058. The Arab Potash Company employs over 2000 personnel and has offices in Amman, Safi and Aqaba. It owns extensive housing and recreational facilities near its plants, and in addition, it provides the surrounding region with assistance in social, medical, economic and vocational development.

2.16 "APC" Departments:

APC is considered a large company, and to control it and let it works very perfect; then it must be divided to different departments:

1. General Management Department contains:

   (Marketing, Economy Business, Accounting………… etc)

2. Planning & Development Department.

3. Production Circle (Factory):

   - Cold Crystallization Dep.

- Ø Hot Crystallization Dep.
- Ø Harvesters Dep.

4. Energy & water Department.
5. Maintenance Circle :
   - Ø Engineering Workshop.
   - Ø Heavy Automobile Service.
   - Ø Light Automobile Service.
   - Ø Procurements
6. Electricity Department.
7. Technical Department (Laboratories)
8. Communications & Information Technology Department.
9. Transport Department.
10. Civil Working Department.
11. Industrial Safety & Hygiene Department.
12. Training Department.

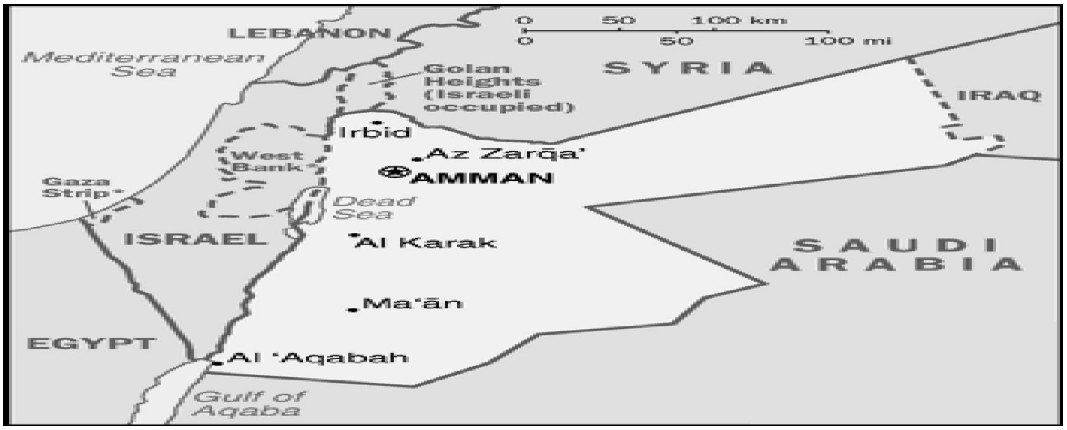
And some other departments.

2.17 Dead sea:

Dead Sea is a terminal lake of the Jordan Rift Valley bounded on the east by Jordan and on the west by the West Bank and Israel Fig.(3.2) The Dead Sea is the lowest point on the surface of the earth, and its waters have the highest density and salinity of any sea in the world. Dead Sea, for centuries, has been receiving the waters of the Jordan River, wades, and the springs but due to evaporation very slowly concentrating the salts into what has become one of the greatest mineral reservoirs known to man. The level of the Dead Sea has been declining since the beginning of the century. The origin of the salts is believed to be a leaching of soluble salts from the surrounding areas through the ages. The local climate of the Dead Sea is extremely arid and hot. The rate of water evaporation is relatively slow

because the water's dissolved salts lower the vapor pressure over the surface. Deep in the Jordan Valley and 55km southeast of Amman, is the Dead Sea, one of the most spectacular natural and spiritual landscapes in the whole world. It is the lowest body of water on earth, the lowest point on earth, and the world's richest source of natural salts, hiding wonderful treasures that accumulated throughout thousands of years [24].

Fig (2.1): Dead Sea Location Map



As its name evokes, the Dead Sea is devoid of life due to an extremely high content of salts and minerals which gives its waters the renowned curative powers, therapeutic qualities, and its buoyancy, recognized since the days of Herod the Great, more than 2000 years ago. Scientifically speaking, its water contains more than 35 different types of minerals that are essential for the health and care of the body skin including Magnesium, Calcium, Potassium, Bromine, Sulfur, and Iodine.

They also provide the raw materials for the renowned Jordanian Dead Sea bath salts and cosmetic products marketed worldwide. Dead Sea Bath Salts can also be used as a raw material in the cosmetic industry.

Table (2.2): Dead sea composition (by weight) and reserves [28]

Composition	Weight %	Amount (tons)
Magnesium chloride	14.5	22 billion
Sodium chloride	7.5	12 billion
Calcium chloride	3.8	6 billion
Potassium chloride	1.2	2 billion
Magnesium bromide	0.5	1 billion
Water	72.5	-

Table (2.3) Dead Sea dimensions [18]

Max. length	67km (42mi)
Max. width	18km (11mi)
Surface area	810 km2 (310 sq mi)
	North Basin
Average depth	118m (387ft)
Max. depth	378m (1,240 ft)
Water volume	147 km3 (35 cu mi)
Shore length	135km (84mi)
Surface elevation	-422m (−1,385 ft)

2.18 Potash:

Potassium is the chemical element with the symbol K , atomic number 19, and atomic mass 39.0983. Elemental potassium is a soft silvery-white metallic alkali metal that oxidizes rapidly in air and is very reactive with water, generating sufficient heat to ignite the hydrogen emitted in the reaction. Potassium and sodium are alkali metals and are chemically very similar. For this reason, historically their salts were not differentiated. They were finally realized to be different elements when the metals were isolated by electrolysis in the early 19th century. Potassium in nature occurs only as ionic salt. As such, it is found dissolved in seawater (which is 0.04 % potassium by weight), and as part of many minerals. It is found in especially high concentrations within plant cells, and in a mixed diet, it is most highly concentrated in fruits. The high concentration of potassium in plants, associated with comparatively very low amounts of sodium there, historically resulted in potassium first being isolated from the ashes of plants (potash), which in turn gave the element its modern name. Heavy crop production rapidly depletes soils of potassium, and agricultural fertilizers consume 93% of the potassium chemical production of the modern world economy. The functions of potassium and sodium in living organisms are quite different. Animals, in particular, employ sodium and potassium differentially to generate electrical potentials in animal cells, especially in nervous tissue. Potassium depletion in animals, including humans, results in various neurological dysfunctions. Elemental potassium does not occur in nature because it reacts violently with water. As it is very electropositive and highly reactive potassium metal is difficult to obtain from its minerals [8].

Table (2.4) Number of chemical compounds containing potassium [8]

Common Name	Chemical Name	Formula
Potash fertilizer	potassium oxide	K_2O
Caustic potash or potash lye	potassium hydroxide	KOH
Chlorate of potash	potassium chlorate	$KClO_3$
Muriate of potash	potassium chloride	KCl
Nitrate of Potash or salt peter	potassium nitrate	KNO_3

2.19 Potassium Chloride:

Table (2.5) Kcl physical properties [8]

Molecular Formula	KCl
Molar mass	74.551g/ mol
Appearance	white crystalline Solids
Density	1.987 g/cm^3
Melting point	776°C
Solubility in water	28.1g / 100 cm^3(10°C) 34.0 g/100 cm^3 (20°C) 56.7 g/100 cm^3 (100°C)

The chemical compound potassium chloride (KCL) is a metal halide salt composed of potassium and chlorine. In its pure state it is odorless. It has a white or colorless vitreous crystal, with a crystal structure that cleaves

easily in three directions. Potassium chloride crystals are face-centered cubic. Potassium chloride is also commonly known as "Muriate of Potash". Potash varies in color from pink or red to white depending on the mining and recovery process used. White potash, sometimes referred to as soluble potash, is usually higher in analysis and is used primarily for making liquid starter fertilizers. KCL is used in medicine, scientific applications, food processing. It occurs naturally as the mineral sylvinite an in combination with sodium chloride as sylvinite.

2.20 Potash Plant Layout:

Definition of plant layout "it is the arrangement of machines within a factory, so that each operation is performed at the point of greatest convenience." Plant layout may also be defined as " a technique of locating different machines and plant services within the factory so that the greatest possible output of high quality at the lowest possible total cost can be available." Proper plant layout is one of the keys of success in factory management. It signifies arrangement of machines, work area, transport, storing of material and processing of different parts. The layout for the same product may be numerous but which costs less to process is the best.

Main objectives of scientific layout:

i. To produce better quality products
ii. Maximum utilisation of floor area
iii. To produce internal transport from one operation to the next as much as possible.
iv. Lighting and ventilating of areas.
v. Lower cost of scrap and waste.
vi. Fewer accidents.
vii. Minimizing production delays.
viii. Space for future expansion.
ix. Safety of equipment and personnel.
x. Better working conditions for both executive and operative employees.
xi. Avoidance of unnecessary changes.
xii. Saving of coasts.
xiii. Easy supervision.
xiv. Neatness.
xv. Proper production control.
xvi. To estimate waste effort and speeding of production.

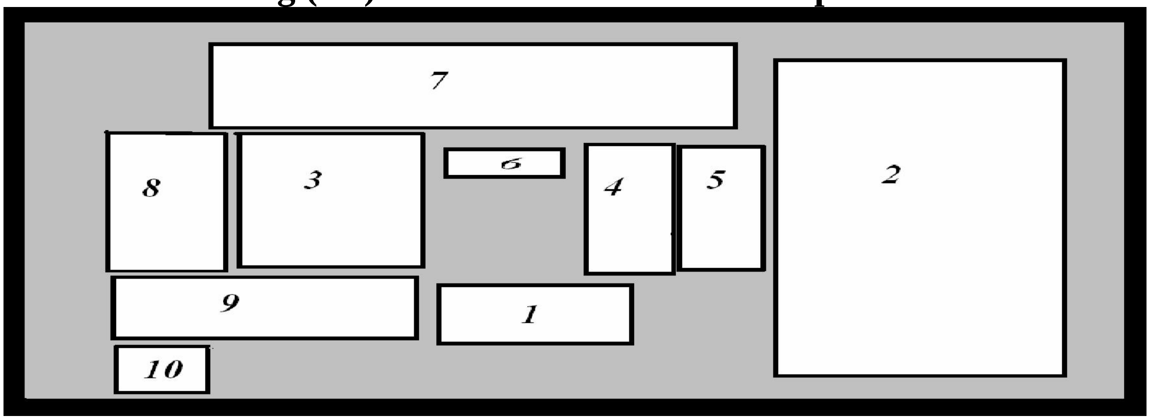
2.21 Principles Of Plant Layout:

According to Muther, there are six basic principles of best layout [3].
These are:

1. Principle of overall integration:
   According to this principle, the best layout is one which integrates the men, materials, machinery, supporting activities and any other such factors those results in the best compromise.
2. Principle of minimum distance:
   According to this principle, other things being equal, the best layout is one which men and materials have to move the minimum required distance between operations.
3. Principle of flow:
   Muther said that, other things being equal, the best layout is one which arranges the work area for each operation or process in the same order or sequence that forms, treats or assembles the materials.
4. Principle of cubic space:
   According to this, the best layout is one in which all the available space both vertical and horizontal is most economically and effectively used.
5. Principle of satisfaction and safety:
   According to this, other things being equal, the best layout is one which makes work satisfying, pleasant and safer for workers.
6. Principle of Flexibility:
   It means the best layout is one which can be adopted and rearranged at a minimum cost and least inconvenience.

The APC site is located 110kilometers south of Amman and 200kilometers north of Aqaba. The site is a Solar Evaporation Pond System of an area of 150 square kilometers and processing plants for the ore. It consist of several department see the following figure (2.2.

Fig.(2.2) General APC Location Map.



For the general APC location Map see the following Areas index:

Table No.(2.6) APC location Area Index for Fig. (2.2)

Area No.	Department Location in the Map
1	Administration
2	Solar Pan System
3	Hot Leach Plant
4	Old Cold Crystallization Plant
5	New Cold Crystallization Plant
6	Industrial Potash Plant
7	Shipping Area And Storage Warehouse
8	Maintenance Location
9	Power Production Station
10	Training Centres

2.22 Production Department:

This department is considered as the most important department; It relates to the production of the final product (POTASH) to markets, and management of this department is rather difficult. This department is divided into three parts:

1. Hot leach plant.
2. Cold Crystallization Factory.
3. Industrial Potash Factory.

The production of potash depends on the physical separation of “KCl” from other content of Dead Sea brine like {NaCl, $MgCl_2$, KBr and water} and the used method is either cold or hot crystallization but in industrial potash production, here, a chemical reaction is used to extract the bromine and replace the chlorine in order to increase purity of the final product [13,14].

2.22.1 Hot Leach Plant:

The first chemical process will be considered is the hot crystallization, the process consists of heating the saturated solution and place it in vacuum to allow precipitation of crystals to be formed in the desired sizes.
This method has features of large production, good product and acceptable to any raw material, but it isn’t safe and has high maintenance cost in addition to the cost of heating.

For better understanding their production process, A suggestion can be made in dividing the factory into five regions:

1. Carnalities Processing: The carnalities slurry is received, dewatered and decomposed with fresh water in agitated tanks. The resulting solids are Salvanite (KCl & NaCl.
2. Salvanite Processing: The Salvanite cake is leached in the tow first stage hot leach tanks with heated mother liquor brine from the crystallization process in addition to unsaturated brine from the second stage hot leach system. Here most of the potassium chloride is dissolved while the remains un-dissolved. Then the solution is discharged to hot thickener to separate the rich stream (over flow) and poor stream (under flow), then over flow to crystallizers and under flow to hot leach second stage.
3. Crystallization Process: Begins from a hot mother liquor hot thickener over flow and depend in cooling and make vacuum to crystallization of potassium chloride.
4. Dewatering and Drying: - It is fed from the slurry of crystallization area, and the first step is to separate the crystals from the brine by -product centrifuges, then drying them by rotary fuel dryer.
5. Screening & Storage region: During the crystallization not all crystals have the equal size, and the price of potash depend on its size. Then we must screen the product into three sizes (coarse, standard and granular (fine. Then the finished product is stored ready for shipping to its purchased destination.

(i)Carnality Surge Tanks:

The first unite of plant and its objective is to store the brine which is fed from harvesters (20 % solid percent contains 84 % carnalities and 16 % NaCl) for blending purposes and isolating harvester operations from plant operations to some degree. There are 4 tanks with configuration of 21.5m in diameter and 16m in height with agitator for every tank to ensure well mixing [13].

(ii)Carnality Centrifuges:

The carnalities slurry is pumped to twelve huge centrifuges, divided into two rows in order to; (1)dewater the most amounts of carnalities, (2)pump the filtrate to carnalities thickener(3)the number of centrifuge depends on the carnalities particles (4)the remaining is discharged to carnality thickener.

The objective of this dewatering is to minimize the amount of magnesium and calcium chloride enters the decomposition tanks, this

will decrease the amount of pure water used to dissolve these salts in the decomposition tanks.

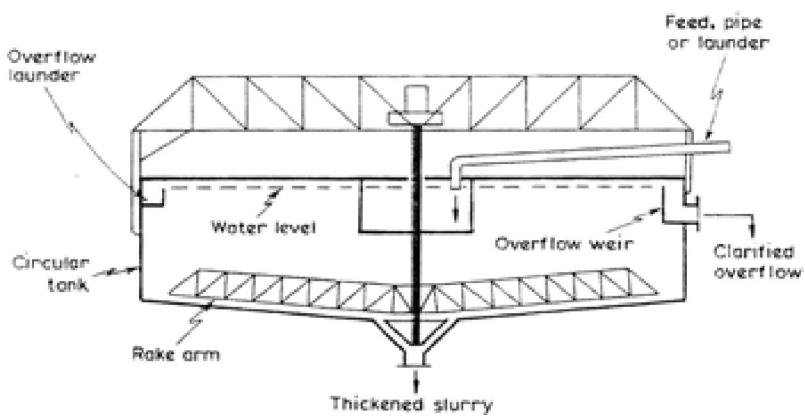
(iii)Carnality Thickener:

Consider that the filtrate of the centrifuge contains some amount of Potassium Chloride, so to attain the maximum amount of brine and increase the production efficiency of plant, the slurry is charged to carnality thickener. The carnalities thickener is a huge tank look as semi cone with average diameter of 52m and about 2m height.

The thickener as all thickener consists of three main parts [19]:

1. Thickener body, where the slurry is carried.
2. The center wheel, at which the feed is pumped in the middle of the thickener and move around itself slowly and convert the transition and turbulent of feed flow to laminar tangential flow to start the thickening process.
3. The rake arm, its role to well mix the slurry and drift the heavy mixture to centered of thickener. As shown bellow in fig. (2.3.

Fig (2.3) Design Picture of a thickener



(iv) Decomposition tanks:

The centrifuged carnalities cake is discharged to decomposition tanks by conveyor belts to dissolve magnesium chloride present in and reach a minimum amount of 0.1% volume at the end of this second stage of processing. For this purposes, Six tanks are used each with a capacity of $700m^3$ with large agitator, and the amount of fresh water added is controlled automatically by the weight of discharged carnalities on the belt. Water decomposes the carnalities to produce potassium chloride, magnesium chloride and the hydrated water in carnalities crystals goes to the solution with small amount of sodium chloride.

(v) Carnalities Reactor:

A stream from under flow carnality thickener, and under flow stream of decomposition tanks are pumped to a reactor. The design of the reactor is very simple and smart, it contains a huge short agitator inside cylindrical tank, and the agitator revolves in a draft tube of cone and the down part of draft tube is cylinder; and this design is to ensure well mixing and separating by density. In addition to riser to take only the product from the bottom of the tank (heavy).

(vi)Wash Thickener:

The over flow of the reactor is pumped to wash thickener to collect the largest amount of carnalities and pump it to the decomposition tank again throughout under flow wash thickener stream. The poor solution in carnalities is then returned to the surge tank.

(vii) Salvanite Thickener:

After removing the Mage ($MgCl_2$) the slurry is made to settle in 30m thickener called Salvanite thickener and only receives the under flow which contains about 30% solid. Before this, the salt screen are added; because previous studies showed that this screen removes a large amount of NaCl as result.

(viii) Belt Filter:

This unite from its name is dewatering unite for Salvanite and its principle is to filtrate the slurry by inducing vacuum under the moving belt filter to remove the amount salts and all traces of colloidal $MgCl_2$ and preparing to hot leach step. Two filters are operated in parallel.

Up to this point, the separation of $MgCl_2$ from solution and with % that does not exceed 0.1 % in solid content, and the solution contains only " NaCl" & "KCl" with volume 56 %, 44 % respectively. And here, the major problem arise is how to remove the maximum amount of "NaCl" by dissolving & extracting the maximum amount of KCl [13, 19].

(ix) Hot Leach Tanks:

The principle of hot leaching tank: This unit depends on the behavior of potassium chloride, and sodium chloride in water, and the effect of temperature on their solubility in respect to solution thermodynamics laws and solubility.

From the chart of thermal solubility, it is important to note that:

1. The solubility of NaCl is greater than the solubility of KCl at ambient condition.
2. The solubility of NaCl is equal to the solubility of KCl at moderate temperature.

3. The solubility of KCl is greater than the solubility of NaCl at high temperature.
4. The solubility of NaCl is proportional inversely to temperature in almost linearly.
5. The solubility of KCl is proportional to temperature in almost fractionally.
6. The optimum working condition is the maximum temperature, but we can't work at temperature larger than 110°C; because of the presence of aqueous solution boiling point must not reached, otherwise vapor will be generated, and that is impossible to control.
7. Finally, the best temperature is between 105°C & 110°C.

At the end of this step the mother liquor will be rich enough in KCl With small amount of NaCl and need be thickened for crystallization. After which, the mother liquor is charged to hot thickener, and then to crystallizers.

(x) Crystallizers:

Crystallization is an important operation in the chemical industry, as a method of purification and as a method of providing crystalline materials in the desired size range. In a crystal the constituent molecules, ions or atoms are arranged in a regular manner with the result that the crystal shape is independent of size, and if a crystal grows, each of the faces develops in a regular manner. The presence of impurities will, however, usually result in the formation of an irregular crystal [35].

The crystallizer is a draft tube_ baffle design, the agitator circulates the crystal slurry from the bottom to the evaporation surface (top) through the draft tube. This feature allows the crystals and the supersaturated brine formed at the surface to come in to almost immediate contact, enhancing crystal growth. And the principles of precipitate the content of "KCl" is to reduce the solubility of solution suddenly by cooling the brine suddenly by condensers and make vacuum inside the crystallizer. To accomplish this, it is required that;

1. Ejectors: to achieve the desired vacuum, depends on the flow of the steam through the venture to Rarefaction the pressure inside the crystallizer to absorb vapor.

2. Condensers: cools the solution inside the crystallizers, here, the mother liquor which returns to hot leaching area in the first three crystallizers. Using "Barometric condensers" in addition to heating the mother liquor, saves 183 million Btu/hr (51 % of the heat required) and raise the mother

liquor temperature from 49°C to 81°C. The second source of cooling is the Salvanite thickener under flow and Carnality thickener overflow.

Operating Procedure:

The slurry comes from hot thickener enters the crystallizer from the bottom and it is the solid potash and its temperature is about 90°C (19%KCl & 12%NaCl) and with another unsaturated feed from the bottom also, in addition to a fresh water feed to keep the level in the crystallizers is constant and recover 70% the amount of evaporation. The cooling slurry is added from top, and insures good distribution the penetrated pans.

The output over flow of the first is pumped to second to let the crystals grow, The product of crystallizers is 35% coarse size, 65%, And product purity approaches 98.1% KCl.

The crystallizers must be washed internally by fresh water from periodically to remove the potassium chloride crystals that have accumulated in the internal vessel body.

Solid in all crystallizers must be controlled using density meters readings, because it is the main factor in the process of crystallization.

(xi) Product Dewatering & Drying:

Slurry discharged from the fifth stage crystallizer is concentrated to 0.5 wt in the product hydro cyclones, the under flow in addition to underflow from mother liquor tank flow by gravity into surge tank.

Hydro Cyclones:

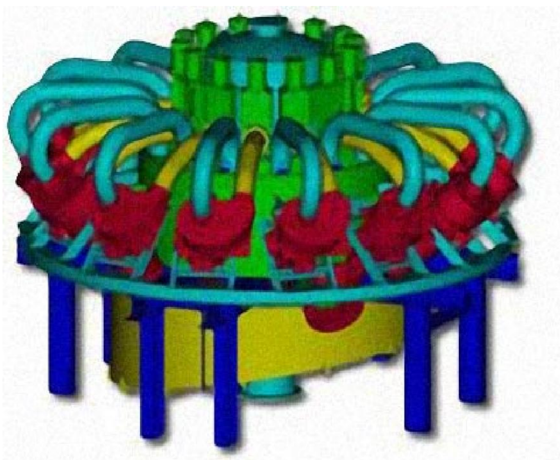
A cyclone is a commonly used apparatus that makes use of gravity and centrifugal force to separate solid particles from a gas stream.

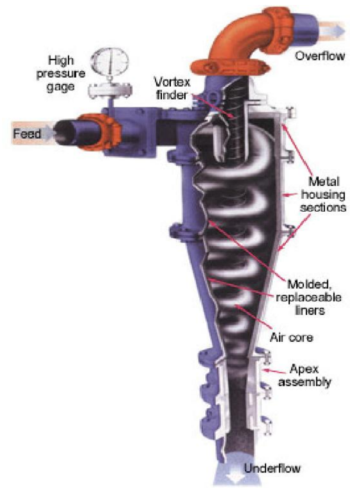
A typical cyclone consists of cylindrical vessel with a tangential inlet and top and bottom outlets. Cyclones are widely used in various industries because they are easy to build, inspect and maintain see fig. (2.4.

Hydro cyclones operate under pressure. The feed, a mixture of possibly gases, liquids and solids enters the hydro cyclone tangentially through the inlet which forces the mixture to spin inside the cyclone. This spinning motion generates centrifugal forces which cause the gas to disengage quickly and exit through the vortex finder. The liquid passes down into the conical section where the reduction in diameter accelerates the fluid thus generating centrifugal forces strong enough to cause the solids to separate from the liquid. The solids are forced towards the wall, because of density difference, and then travel down the length of the conical section of the hydro cyclone in a spiral pattern towards the solids outlet, termed the underflow. The gas and liquids migrate towards the center of the hydro cyclone where the flow reverses and

moves upwards towards the over-flow, through the vortex finder. Separated solids fall down under gravity into the accumulator vessel situated beneath the hydro cyclone [19].

Fig.(2.4) Hydro cyclones simulations





After that, slurry is fed to three product centrifuges for dewatering and separation of Potash as wet cake (contains about 5%water), the poor slurry is returned to mother liquor loop again. Then to dry the cake perfectly the cake is charged by conveyed belt to product rotary dryer to reduce the humidity to less than 0.1 %.

Dryer: the drying of materials is often the final operation in manufacturing process and is carried out immediately prior to packaging or dispatch. By drying, the final removal of water. The rotary dryer is employed to reduce or minimize the liquid content of the material it is handling by bringing it into direct contact with a heated gas. The dryer is made up of a large, rotating cylindrical tube, usually to convey the material through the dryer. Gravity to be as the dryer rotates; the material is lifted up by a series of internal fins lining the inner wall of the dryer. When the material gets high enough to roll back off the fins, it falls back down to the bottom of the dryer, passing through the hot gas stream as it falls. This gas stream can either be moving toward the discharge end from the feed end (known as co-current flow), or toward the feed end from the discharge end (known as counter-current flow. The gas stream can be made up of a mixture of air and combustion gases from a burner, in which case the dryer is called a direct heated dryer. Alternatively, the gas stream may consist of air or another (sometimes inert) gas that is preheated. After dryer and on the

air output there is a dust cyclone to remove the most traces of potash dust which air carried it during drying; to reduce the losses in product and not to pollute the environment.

(xii) Screening & Compacting:

The screening and compacting system produce three product grades; coarse, standard and granular with 30%, 50% and 20%, respectively. The product of dryer is fed two bin.

1. From dryer to main feed surge bin:
   Product from dryer is fed by screw conveyor to the main feed bucket elevator(160MTPH) with continuous mass flow device and speed monitor, finished _the elevator_ with three outlets which in turn feed the main feed surge bin (250 metric tons. Dust is collected through collection points on the discharged hood.
2. From dryer to compaction feed bin:
   Dust from the dryer cyclones and the electrostatic precipitator (1.5 -2.0 MTPH) flow from the tow cyclone screw conveyors to the compaction feed bin by an elevator.

(xiii) Product Processing:

The product is sold in three sizes: standard, fine, and granular. To achieve these desired sizes the product is sieved and screened to separate the standard from the fine product, and to get the granular product, part of fines is compacted, crushed, and screened to obtain the desired granules size.

1. Primary Screens**:**
   These are six parallel screens in which extra coarse particles are separated from the dried product. These coarse particles are crushed and recycled to primary screens for further screening.
2. Secondary Screens:
   The undersize of primary screens consists of both standard and fine size particles, which are separated in the secondary screens. Fine particles are fed to fine product bin, while standard particles are fed to potash cooler.
3. Potash Air Cooler**:**
   This is a vibratory mesh cooler in which air at the ambient temperature cools hot standard product. Air flow in a cross flow with solids to maximize cooling efficiency. The cooled standard product, at 80C°, is fed to standard product bin.
4. Compactors:
   Due to market demand, part of fine product is compacted in two parallel roller compactors to produce compacted flakes of potash.

Should flakes pass compactors' rollers, they pass through flake breakers to break them into smaller pieces in order to facilitate their flowing and conveying.

5. Hammer Screens**:**

   These two screens are used to separate extra coarse flakes out of compactors' output. These extra coarse flakes are then fed to crushers to be crushed and recycled to hammer screens for further screening. Undersize of hammer screens is fed to screens for further screening. Each hammer screen is vibrated, or hammered, by three vibrators, which have two-directional motion: up and down.

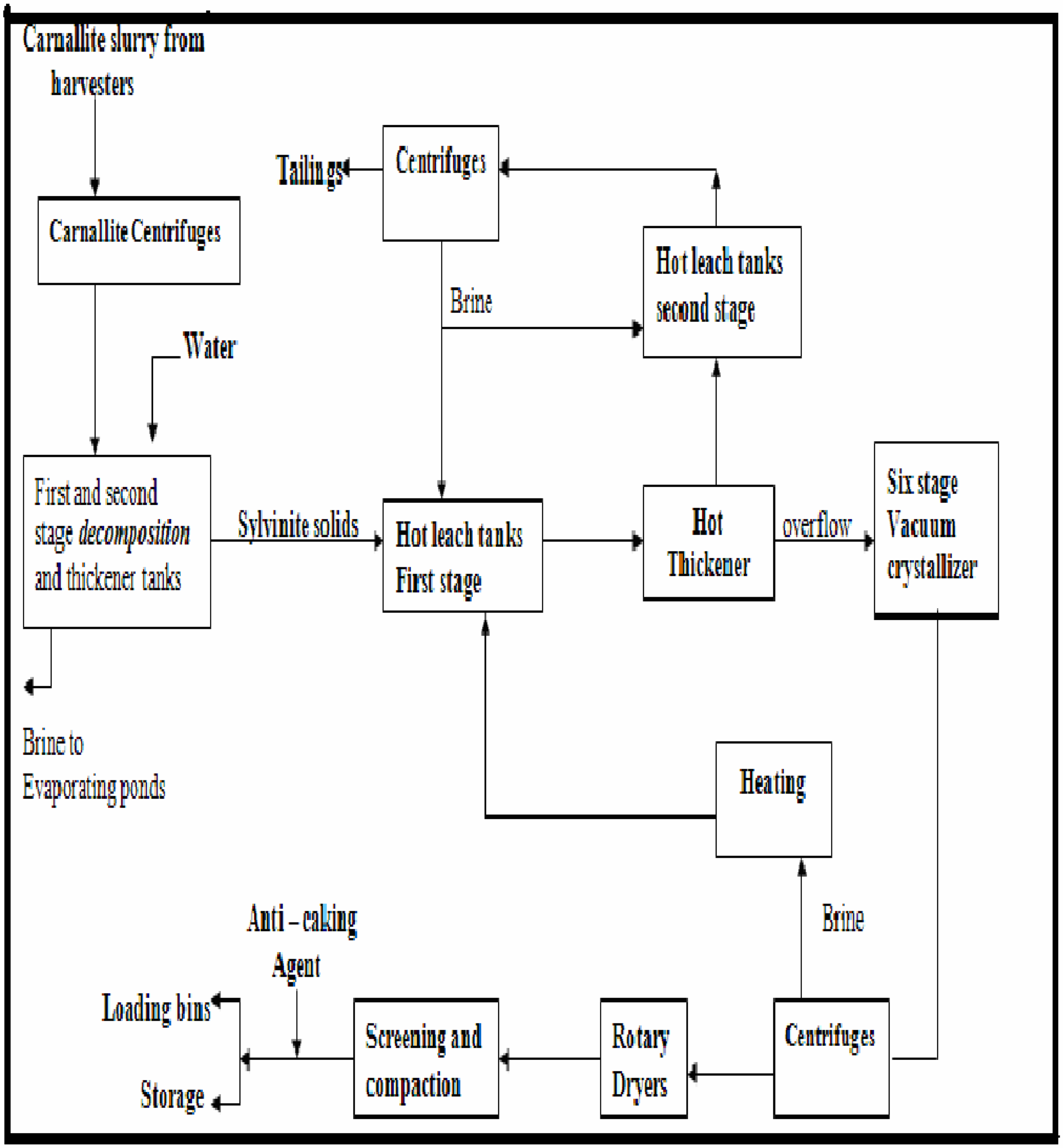
6. Granular Grade Screens:

   These four screens are applied to separate potash granules from finer particles. Granular product is fed to granular product bin, while finer particles, i.e., undersize, is recycled to compactors. These screens have a horizontal plan motion as that of primary and secondary screens.

7. Shipping Area:

   Different grades of potash: fine, standard, and granular, are conveyed from their surge bins to either warehouse or shipping bins in order to be transported to Aqaba. The warehouse has a capacity of 60000 ton and equipped with several belt conveyors to facilitate product conveying to and from, see fig.(2.5) the Schematic block diagram of hot leach plant.

Fig.(2.5) Hot leach plant schematic diagram



2.22.2 Cold Crystallization Plant:

Any one of the six harvesters may be used to provide feed to the cold crystallization plant. The production of 400.000 Ton / year potash products requires 253.1 Ton / Y pure carnalities, or 301.4Ton/ year crude carnalities containing 16.0% sodium chloride. Since a single harvester will not provide this quantity, about 26% of the total carnalities is pumped from one of the existing carnality surge tanks [13].

Efficient operation feed to the plant must be of constant quantity and quality. Raw carnalities slurry flows up through a riser in the carnality receiver tank to the pump box that feeds the two carnality screens. Since it is not practical to homogeneously suspend the larger carnalities and sodium chloride particles, the larger size (greater than 1.4mm) are separated as oversize by the two carnality screens and stored in a live bottom two hour surge bin located directly below the screens. Extra capacity and brine sprays are provided for the screens to accommodate large changes in the harvester slurry. A scalping section on the carnality screens separate the plus 25-mm material, usually rocks and trash.

When the harvester brine is mixed with downstream crystallizer discharge brine, carnalities is precipitated. The precipitated carnalities can be recovered by mixing brine contained in the carnality screens undersize slurry with brine discharge from the first-stage crystallizer overflow in the agitated reactor tank, upstream of the carnality thickener. To maximize crystal size of the precipitated carnalities so that, it will settle in the carnality thickener, the crystallizer brine is introduced through the inlet side of the reactor impeller, about 10% of the carnalities produced by the reaction is assumed to be lost in the carnality thickener overflow.

Oversized solids from the carnality screens are low in sodium chloride solids, which are removed later in the process by screening. The screens undersize must be beneficiated by sodium chloride floatation before it can be used in the cold crystallization process. In the flotation process 45% slurry from the carnality surge tank is treated with a small amount of flotation reagent. As the slurry is fed to the bank of flotation cells, it is diluted with brine from the downstream flotation thickener overflow in the flotation feed tank (one-minute retention), to give a slurry contacting about 23% solids.

In the flotation cells, air is dispersed into the slurry, the reagent, which has coated the NaCl particles, causes them to adhere to the air bubbles and float to the surface where they are continuously skimmed off by the froth paddles. The carnalities, (which is not coated with the flotation reagent), passes through a series of five cells and is withdrawn as slurry at the end of the bank. The carnality, after passing through flotation is upgraded to about 5% sodium chloride. About 95% of the carnality entering the cell bank is recovered in the sink.

The sodium chloride contained in the flotation cells flows by gravity to the agitated tails disposal tank.

Carnality slurry in the flotation cells underflow (sink) must be dewatered before it is fed to the cold crystallization process. The first step in dewatering down to 7% brine is achieved in worm-screen carnalities centrifuges. The centrifuge screens require a minimum of 40% solids in the feed slurry. Ten centrifuges are provided.

Feed slurry is pumped from the fine carnalities surge tank to two carnality centrifuge splitter boxes from which the slurry flows by the gravity to carnality centrifuges. Entrained air in the centrifuge effluent is disengaged from the fluid by centrifugal action. The effluent flows by gravity to the feed launder of the flotation thickener. The centrifuge cake is collected on a belt conveyer and fed into the downstream crystallizers.

The agitated fine carnality surge tank provides a maximum of one-hour surge before the final carnality-dewatering step by the carnality centrifuges. Carnalities feed to the cold crystallizer consist of carnalities screen oversize (coarse carnalities), which is stored in the coarse carnalities storage bin, ant the carnality centrifuge cake (fine carnalities. The coarse carnality storage bin discharges the solids, at a controlled rate. Re-pulping of the carnalities is done by bleeding slurry from the first-stage crystallizer at 25% solids and pumping the resulting slurry containing the carnality screens oversize solids, back into the first-stage crystallizer at 45% solids. The carnality centrifuge cake (fines) is distributed between the first-stage and second-stage crystallizer in any desired proportion. For the flow sheet material balance, fines to the first-stage crystallizer was set to give 60% of the total carnalities feed to the first-stage, which requires 29% of the fines split off the first stage.

For the maximum recovery in the crystallizer, where brine is discharged from the crystallizer system, must be kept saturated with carnalities at its triple point (saturated with carnalities, KCL and NaCL.

To ensure that the first-stage crystallizer brine is saturated with carnalities remains in the slurry. Too much water addition in this stage will result in lower recovery, and could cause unsatisfactory carnalities dissolution in the second stage. The addition of water to carnalities KCL.MgCL2.6H2O causes dissociation into its components. Crystal growth of KCL crystals in the crystallizer is of utmost importance to minimize nucleation leading to undesirable fines. The fines destruction system is designed to destroy fines by removing them in a brine stream followed by dissolution with water. Slurry from the first-stage crystallizer at 25% solids is pumped to the second-stage crystallizer where the remaining carnalities cake is also added.

Excess water is added to the second-stage to dissolve all the carnalities as it is practical and ensure that the brine is slightly unsaturated

with carnalities. The carnality instauration for design purposes is such that the brine contains 0.5% more KCL, 0.64% more NaCl, and 1.44% less MgCl2 than it would, if fully saturated with carnalities. Overflow brine from the second-stage crystallizer overflows to the product thickener. Clarified product thickener overflow brine is distributed to the first-stage and second-stage crystallizers. Brine entering the first stage from the second stage will contain more dissolved KCL and NaCl than that brine in the first stage which will cause these components to precipitate and be returned to the second stage as solids. Assuming a constant degree of carnalities saturation in the second stage brine, the same quantity of these components will be re-dissolved then returned to the first stage as dissolved solids and thus constitutes a recalculating load of KCL and NaCl. Constant quantity and quality of carnalities feeds and water addition to the crystallizer are important. For instance, a change in carnalities or water addition could cause an increase in $MgCl_2$ concentration in the second-stage crystallizer brine. When the crystallizer system contains too much fine NaCl, which the crystallizer screen cannot remove as oversize, it must be removed by lowering MgCL2 content of the first stage. Since more KCl will also be bled off the first stage crystallizer over flow brine alone with the NaCl, KCl recovery will adversely be affected.

Slurry discharged from the second stage crystallizer will contain all the KCl precipitated from both crystallizers and any un-dissolved NaCl and carnalities. The slurry is pumped to the crystallizers screens where the plus 800-micron solids are screened off and fall into the tails disposal tank located directly below the screens. Most of the NaCl crystals fed to the first-stage crystallizer from the coarse carnalities storage bin are expected to be screened out here, plus a small amount of the largest carnalities particles remaining un-dissolved.

Crystallizer screens undersize slurry passes through a series of two agitated first-stage product leach tanks giving thirty minute retention effluent from the first-or second-stage product centrifuges can also be added to either or both of these tanks. Piping arrangement is made such that water can be added to these tanks for dissolution of fine carnalities and NaCl solids in any proportion to maintain product grade. Slurry from the product leach tank flows to the product thickener by gravity. Here, the slurry is thickened to 45% solids prior to being fed to the warm-screen first-stage product centrifuges. The 20-m diameter thickener has a clarified brine storage capacity of $9000m^3$ which can serve to empty, or fill one crystallizer when taken out of service.

Product thickener underflow slurry is pumped to the three first-stage product centrifuges, the fourth centrifuges are provided as a standby. Process water which is provided for centrifuge cake to remove as much of $MgCl_2$ from the product cake as is practical. 60% removal of the brine is

expected when adding 150liters per ton solids feed. About 70% of the water added will leave the centrifuge in the effluent, after air disengagement, flows by gravity back to the first product leach tank, where leaching benefit is obtained from the wash water that it contain.

Product centrifuge cake is conveyed to the product dryer which is a co-current rotary, direct fired tape. The solids exit the dryer at 150°C. In the cooler, the product is cooled to 90°C (the maximum temperature desirable for shipment) by direct contact with atmospheric air flowing counter- current to the solids. Gases from the dryer pass through high efficiency cyclones for dust removal before being exhausted to atmosphere.

A screw conveyor between the dryer and cooler serve as an air lock. Cooler discharge solids will be conveyed to a bucket elevator in the product screening section of the plant. Tramp iron is removed in the elevator discharge chute by a permanent magnet. Lumps created in the dryer together with any material larger than 6.3mm (Tyler 3 mesh) are removed by the vibrating scalping screen. Oversize falls into a hammer mill crusher after which it flows by gravity back to the boot of the product elevator.

Scalping screen under size is distributed to five high-frequency vibrating product screens by a vibrating pan conveyor. Any product remaining at the end of the conveyer is returned to the boot of the product elevator to be redistributed to the product screens. Product screens oversize and undersize are conveyed to the appropriate 250ton standard and fine bins to wait dispatching. The pins have activated bottoms to aid in trouble free discharging.

Each of the dispatch bins is discharged at a constant volumetric rate of about 300 TPH by a screw feeder, after the material has been conveyed from beneath to the bin discharge; the flights are changed so that the screw is only partially filled hereafter. This is done so that anti-caking material can be applied and mixed thoroughly with product before it is discharged onto the downstream belt conveyer. Anti-caking amine can be applied to the product either as solution dissolved in diethyl glycol or in solid flake form. The product is conveyed to above the existing shipping bins with inclined belt conveyers. From here standard product will usually be transferred into the existing bins and fine product transferred into the product storage bins.

2.22.3 Industrial Potash Factory:

The crude salt is taken over at the APC plant feed tie-in and mass controlled fed into the dissolving station via the screw-conveyor. For dissolving a kind of FC crystallizer is used because of the intense slurry handling. It consists of the dissolving tank, heat exchanger, and circulation

pump and circulation line. The station is operated with the preheated mother liquor return from the crystallizer section (from pump. The crude salt is fed continuously controlled by the suspension density of about 10 to 20 % of crude salt, thus assuring saturation with potassium chloride. The dissolution takes place at about 95°C; this temperature of 95°C is kept constant and controlled by adding heat in from of steam to the heat exchanger.

The solution, produced this way is clarified in the sedimentation part of the dissolving tank. The overflow is flowing with the pump to the heat exchanger (pre heater. The outflow temperature of the solution is kept constant at 106°C by with controlled adding of steam to the heat exchanger. The discharge flow of this heat exchanger is fed to the de-brominating unit. The condensate from these two heaters is collected in the steam condensate vessel. The condensate temperature decreases to 86.5°C by expansion to the direct contact condenser [14]. About 1.4 m/h of the steam condensate is necessary for salt washing in the centrifuge after cooling to 50°C in the plate heat exchanger. The solution is fed with the pump into the top of the stripping column by a flow controlled flap flow control valve (FCV. The temperature of the feed stream is about 106°C. The bromides which are contained in the solution get reacted with chlorine gas into elementary bromine. Therefore chlorine gas is introduced into the middle of the stripping column and also into the feed pipe. The chlorine gas will be produced by giving a solution of 13% sodium hypo-chloric acid and the added sodium hypo chloride are building chlorine gas, NaCl and water. The liquid phase flows into the middle of the stripper column. The arising bromine and the surplus chlorine gas get stripped out of the column using steam for stripping with a working temperature of 124°C and a working pressure about 2.2 bar abs. The neutralization and reduction of the de- brominates KCL-solution happens in two separate process-stages. In the first stage the stripped solution flows into the reaction vessel, where the pH-value is corrected from about pH 4 to the neutral point of the fluid by dosing 5 % soda lye with the double-head metering pump into the feed line.

2.23 Industrial Safety:

Millions of industrial accidents occur every year. In these accidents many of workers lose their lives every year in the world. Accidents may cause injury which sometimes results in death or permanent total disablement. Accidents can be defined as “any occurrence that interferes with the orderly progress of activity". Safety is part of everyday living. Safe operating practices and procedures are vital in the drilling business because the work is hazardous, involving massive machinery, heavy tools and great physical strength. When accidents do occur, the work can be a

serious peril to life and limb. Drilling personnel must know how to work safely on a rig in order to protect themselves, costly rig equipment, and the expensive hole being drilled [11].

Definitions:

a. Safety: means freedom form hazard or accidents or keeping one's self or others away from dangers, injuries or deaths as well as freedom from damages of property & environment.

b. Safety engineering: Is the planning and executing of the safeguarding of workers from personal injuries or death and property and environment from damages arising out of an accident.

c. Hazards: Things or conditions that might operate against safety or success, or conditions that might cause injury, death, damages to property or environment.

2.24 Management & Its Responsibilities:

Active participation by all managers of any industrial organization, especially those at the top, in carrying out accident prevention programs is so vital. Without management support the conscientious safety engineer will be in a constant state of frustration; his or her efforts to accomplish the job successfully will be hampered from the start. Avoidance of accidents requires a sustained integrated effort by managers of all departments, supervisors, and other employees at all levels and in all activities. The safety engineer may indicate of what this effort should consist and may determine whether it is being out properly and adequately. Only the managers, however, can ensure that it is a properly intenerated and coordinated activity. The influence of management must be apparent in the safety policies it sets, the degree to which those policies are observed, and the concern with which it treats any violation. Managers must leave no doubts in the minds of employees that they are concerned about accident prevention. The concern to prevent injury and damage must be sustained continually, rather than intermittently or only temporarily being presented with an accident report. Unless management can provide this support, accidents will take place, perhaps repeatedly.

2.25 Arab Potash Company Safety Policy:

Safe operation is a paramount goal and policy of the Arab Potash Company Ltd. They believe that safe operations are also efficient operations. They further believe that employee's safety is best provided by maintenance safe and orderly working conditions, by following safe working practices, and operating the equipment in the prescribed fashion. The employees safety and well- being will not be sacrificed for expediency or for production, managers and supervisors, at all levels, are responsible for insuring that APC safety and health rules are complied with within their

respective areas. Further, safety staff organizations assigned to coordinate and to assist the managers, supervisors, and other employees in carrying out the company's safety programmed. Fundamentally, the employee's safety is their responsibility. They must learn, practice and obey safe practices. They should not jeopardize the safety or well –being of another employee. By consistence attention to safety and by fully cooperating with their employees and supervisors, APC can reach their goal of safe, efficient operations with minimum injuries.

2.26 Losses Due To Accidents:

Now a-days serious attention is being paid in this matter, because now it has been clearly understood that expenses incurred on the workers. These loses can be measured in terms of money [3].

(i. Direct losses.

These are the losses to the employer, which he pays to the worker for compensation. Employer also pays for medical expenses incurred on the worker. These less losses can be measured in terms of money.

(ii. Indirect losses.

These indirect losses arise from the following sources:

Loss of time of the injured person.

Loss of time of his fellow workers, who stop work at the time of accident to help him or to show sympathy or for curiosity.

Loss of time of the supervisors:-

In assisting injured workers.

In investigation and preparing a report of accident.

In making alternative arrangement.

In selecting and training the new workers to fill the vacancy if accident causes death of the worker.

loss due to damage caused to machines.

Loss due to reduction in the efficiency of the worker when he returns after recovery.

Loss due to the reduction in the efficiency of other workers due to fall in their morale.

2.27 Causes Of Accidents:

To minimize the accidents it is necessary to know about the cause of accident. General causes for accident are given below.

Accident due to dangerous machines. These accidents occur from boiler, pressure vessels, prime movers transmission system etc.

Unsafe physical condition . It includes improper guards, improper illumination, improper ventilation, unsafe clothing's.

Moving objects, sometimes moving object or falling object causes accidents.

Personal factors. Sometimes accidents occur due to some personal factors like lack of knowledge, physical weakness.

Unsafe acts. It is violence of commonly accepted safe procedure. These include (i) working at unsafe speed, (ii) loading machines beyond capacity (iii) not using safety devices, (iv) adopting unsafe procedure.

Electrical causes. Some of the important causes are:-

Do not providing proper protecting devices.

No obeying proper instructions and not following safety precautions.

Failure to use insulated pliers, screw – drivers and rubber gloves etc.

Exposure to harmful substances. Injuries due to accidents are also caused due to exposure to harmful substances, like toxic gases, fumes, dust, vapors, mist and aerosols.

2.28 Preventive Measures:

1. Safety guards. By providing safeguards to the machines, accidents can be prevented. Some guards are built into a permanent casing while some are attached afterwards.
2. Fencing. Machine or their parts should be fenced when it is not possible to provide safeguards.
3. All boilers and other pressure vessels must be kept in proper condition. Safety valves, pressure gage and water gages etc. must be examined thoroughly at regular intervals.
4. Hoists, cranes, and lifts etc. must be of sound construction they must be tested periodically.
5. Physical conditions. Sufficient illumination and ventilation should be provided. Floor should be free from oiliness. Floor should be kept clean.
6. Safety measures include special clothing for the protection of body, such as gloves, apron, goggles etc. lose clothing may be a source of danger.
7. Repair work on machines should not be done when its running.
8. All the tools should be kept at their proper places.
9. Chips should be removed by hand.
10. Workers should be trained about correct procedures and they should be educated about safety precautions. Constant warning, publicity and play cards carrying slogans. Are also helpful to reduce accidents.
11. Fire hazard. To avoid the danger, inflammable materials should be kept away from general storage at a safe distance (minimum 50ft or 15.25m. Fire extinguishers should be kept at suitable places.
12. Prevention of electric accidents. To prevent electric accidents. Following measure should be taken:
    a. Electric insulation should be periodically tested.
    b. Use proper tools for testing and repairing.

c. Work should be done after switching the power off.

d. Use such safety equipments as insulated tools and rubber gloves.

2.29 Personal Protective Equipment:

Some operations require equipment to be worn by workers to avoid injurious effects on the body [11,12].

Managers must ensure that certain rules are observed:

1. For normal operations, first choice will be given to eliminating the hazard in the environment rather than using personal protective equipment.
2. Approved protective equipment and devices must be made available and used to guard against specific hazards that cannot be eliminated.
3. No supervisor will permit an operation to be conducted unless such equipment and devices are in proper working order and used as stipulated by the safety engineer.
4. Only protective and rescue equipment approved for the purpose by responsible agencies.
5. Hazardous operations are conducted only in designated and approved areas.
6. Exits, stairways, and escape routes are marked clearly.
7. Operations are forbidden while winds or rather meteorological conditions could endanger personnel.
8. Open flames or unprotected electrical equipment are not permitted in areas where flammable or explosive materials are permitted.

2.30 Tap Root:

Many companies have the same type of problems that happen over and over again - safety incidents, equipment failures, quality issues, sentinel events, or production upsets. They try different "fixes" but they just don't work. Tap-Root® is a systematic process for finding the real root causes of problems so that you can fix them once and for all.

The Tap-Root ® Enterprise Software helps organize a team's responsibilities, tracks each stage of the investigation process, and allows report approvals and corrective action tracking. Learn to find and fix root causes and develop corrective actions that save lives and prevent injuries. Improve production, maintenance and quality by expertly performing investigations. Phases of Accident Investigation:

Fig. (2.6) phases of accident investigation

2.31Examples [Case Study Document]:

Below is the Taproot report concerning the near miss incident that occurred to APC operator when he was about to fall from the Tails centrifuges' effluent lines floor. The responsible departments for the implementation; verification and validation of the corrective actions are: Production; Maintenance and the rest of the departments for the last corrective action.

Flash Report - Near Miss Incident /FAI

a. They install the report date
b. Classification of Incident: Near Miss Incident/ FAI
c. Plant/Facility: APC Safi Site- Department - Product Area.
d. Time of Incident: 00 :00 AM / PM
e. Account of Incident

After an operator took a sample at the "Sampling Point" to check the solid percentage in the effluent pipe of Tail's Centrifuge #31, he started stepping down on a vertical metallic ladder (about 1.5meters height and consists of 5 steps), at the first step his right foot slipped and he fell on the grating floor, the place is narrow and the lower beam of the protection hand rail was removed, so his body was going to fall down again on the lower floor where many pipes on the grating there, but fortunately he caught the edge by his hands and started calling for help, his supervisor was around and heard him, he was rescued and transported to Plant's Clinic then forwarded to Safi Hospital, X- Ray showed no fractures, only bruises at right shoulder

and small wounds in the left knee, right pinkie and right ring finger, he was given the necessary medicine and reported back to his work.

a. Nature of Incident:

Bruises at right shoulder and small wounds in the left knee, right pinkie and right ring finger.

b. External Agencies:

Name of the hospital

c. Immediate Actions Taken to Prevent Recurrence: Tap Root investigation will be initiated soon.

Summary: An operator had foot slipped from a ladder top to a grating ground (2m height) and his body was hung in the air by grabbing the grating edge with the fingers that prevented him from falling more than 6meters to ground. Initial Conditions: There were residuals of brine leak and oil on the area.

Initiating Event: There were no safety rails at the edge of the area grating.

Corrective Action: 01

This is a generic root cause, so an audit of the plant is to be done. Work orders to be issued to correct the problem actions.

Implementation Due Date:00/00/0000, Verification Due Date: 00/00 /0000 Validation Due Date: 00/00/0000, Associated Causal Factor(s):

The grating edge dose not have the perpendicular edge plate(it prevents objects from rolling out and fall to ground) and the safety rail middle plate was cut previously(only the upper safety rail plate exists .

Corrective Action: 02

Each centrifuge effluent line platform to have their ladders inspected to meet the standard requirements and to re-direct the ladders to the west side away from the safety rails and to consider installing stairs instead of ladders where possible.

Responsible Person/Department: Maintenance

Implementation Due Date: 00/00/0000, Verification Due Date: 00/00/0000 Validation Due Date: 00/00/0000

Corrective Action: 03

All leaks on the centrifuges' effluent chutes and lines to be welded or replaced as needed.

Responsible Person/Department: Maintenance

Implementation Due Date: 00/00//0000, Verification Due Date: 00/00/0000 Validation Due Date: 00/00/0000, Associated Causal Factor(s):

The ladder and the area around have solids and brine residuals from centrifuge leaks and also residuals of oil.

Corrective Action: 04

Instructions to be issued to production staff to report continuously about oil and brine leaks to maintenance and the housekeeping after the leaks (oil & brine) to be followed up to prevent accumulation.

Responsible Person/Department: Production
Implementation Due Date: 00/00/0000, Verification Due Date: 00/00/0000
The ladder and the area around have solids and brine residuals from centrifuge leaks and also residuals of oil Corrective Action: 05:Instructions to be issued to production staff to use safety tapes to surround areas where hazards exist and to continue reporting about it till it is eliminated And since this is a generic root cause; it is required that all departments to issue such instructions.
Responsible Person/Department: Production & All other departments
The ladder and the area around have solids and brine residuals from centrifuge leaks and also residuals of oil.
Table (2.7)For APC safety the annual accident frequency rate (AFR) LTA's per 200,000Man-Hour Worked & the Annual Accident Severity Rate Variation (ASR)[Documents see APC annual report 2008/2009/2010]:

Year	AFR	ASR
2001	4.45	65.5
2002	4.37	68.9
2003	3.46	92.9
2004	2.42	89.5
2005	0.9	679.5
2006	1.14	277.9
2007	1.16	314.8
2008	0.48	21.14
2009	0.81	21.7

Fig.(2.7)For APC AFR Vs time in Year

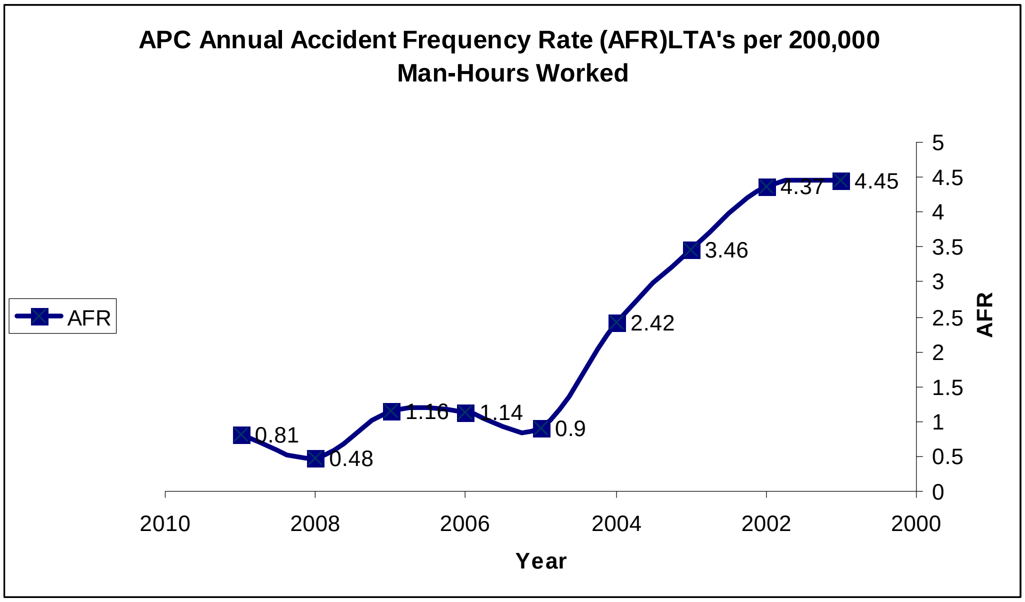
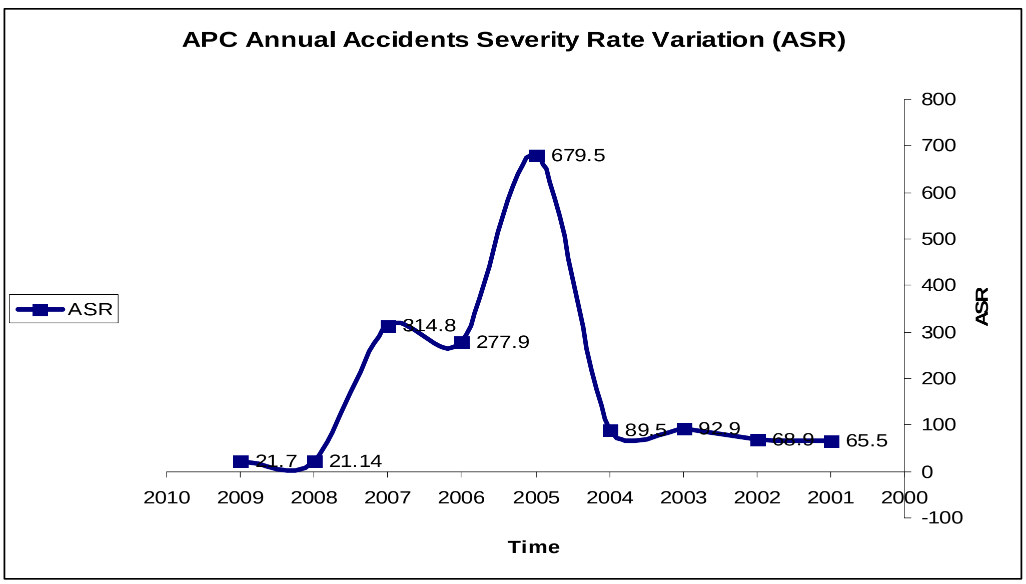


Fig. (2.8) For APC the ASR Vs time in Year.



From figures (2.8) we see that for 2005 there is a sharp increment in ASR caused by several factors such as new expansions. From Both AFR & ASR we calculate the Accident frequency and severity Indicator (FSI) [10, 11]:

Where:

FSI = Accident Frequency and Severity Indicator

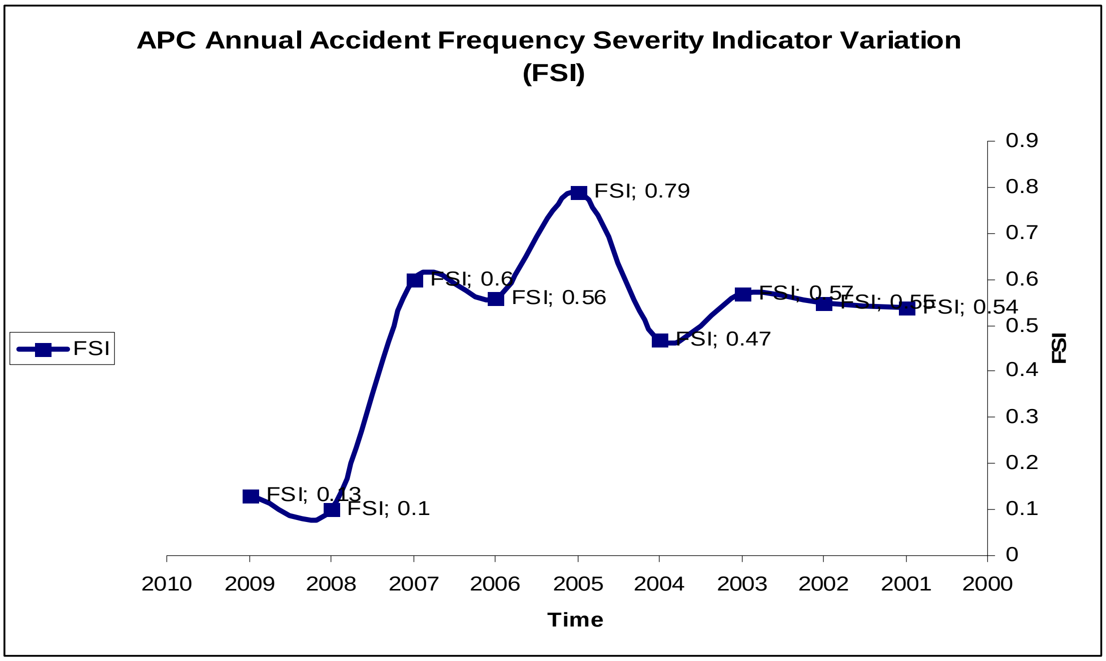
AFR = Accident Frequency Rate = Accidents per 200,000MHW

ASR = Accident Severity Rate = Accidents per 200,000MHW

$$FSI = \sqrt{(AFR * ASR) / 1000}$$

Where [MHR] refers to Man-Hours Worked, then:-

Fig.(2.9) APC FSI Vs time in years



The following Figures show the compliance in several departments with the safety meeting:-

Fig (2.10) Trucking department compliance with safety meeting

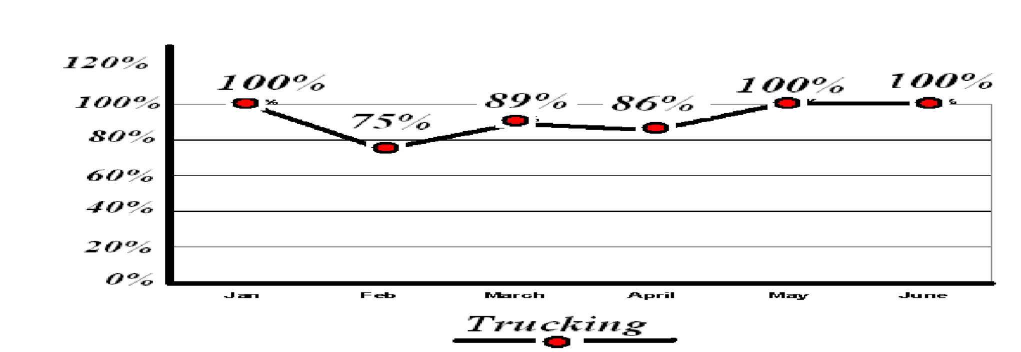


Fig (2.11) Production department compliance with safety meeting

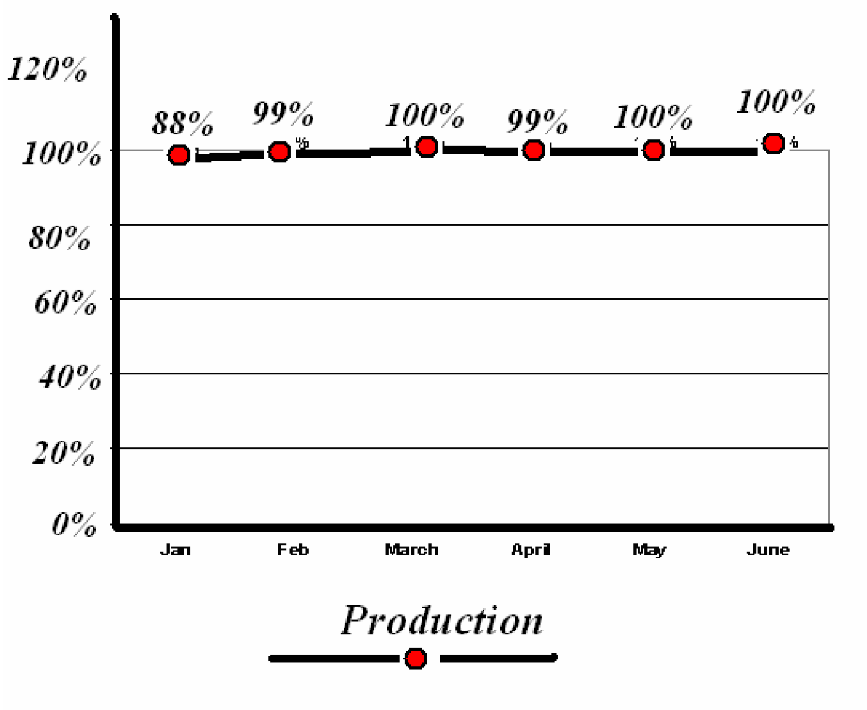


Fig (2.12) Procurement & studies department compliance with safety meeting.

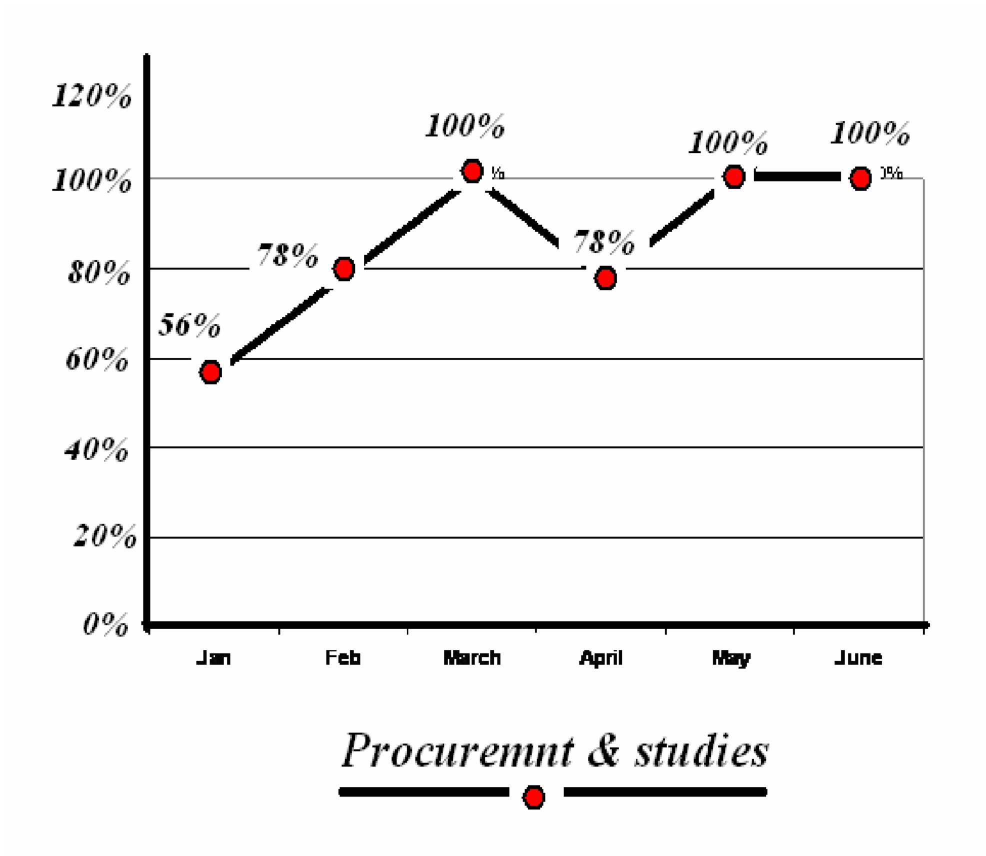


Fig. (2.13) Safety & Environmental compliance with safety meeting

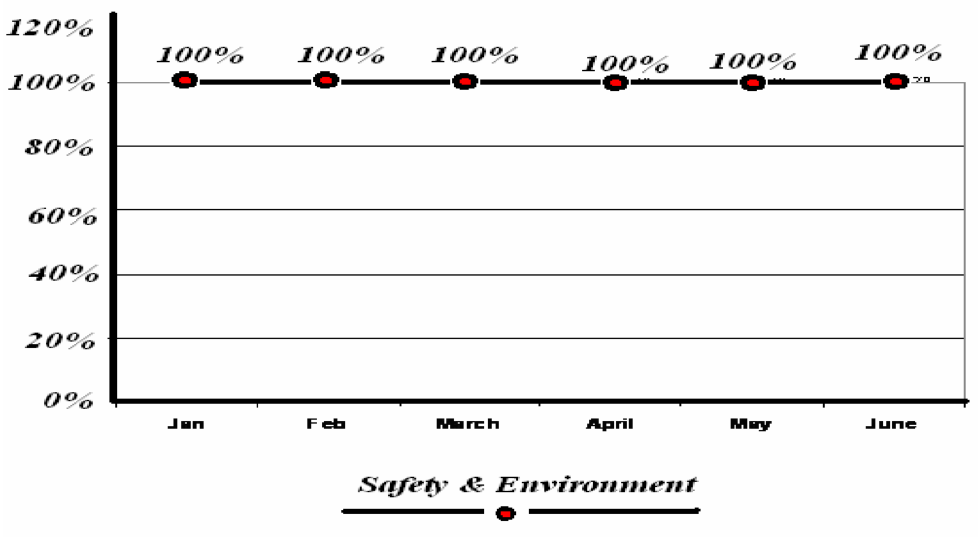
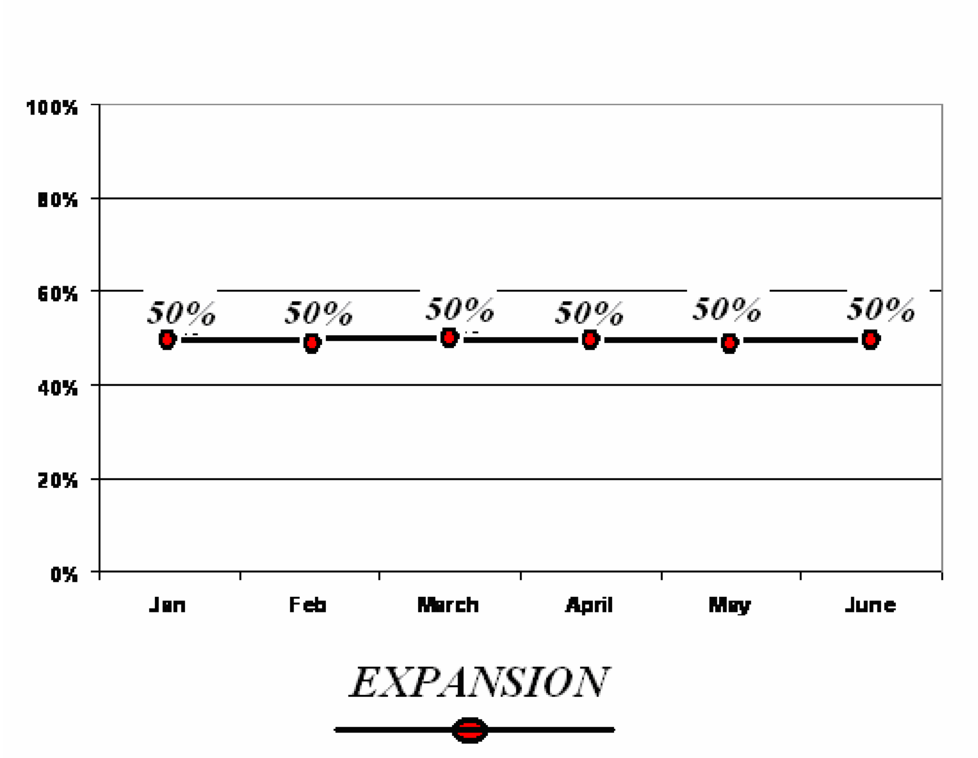


Fig (2.14) Expansion department compliance with safety meeting policy



From figures [2.10 - 2.14] we see that the department can be arranged in there compliance with safety meeting as follows:

1. Safety and environmental departments
2. Production departments
3. Trucking departments
4. Procurements and studies departments
5. Expansions departments.

2.32 Management Attitudes Toward Safety:

It is the management's responsibility to eliminate as much as possible the conditions that bring accidents about. Workers have almost no control over the health hazards of the dust or toxic gases whose effects they do not understand & whose presence they may not even able to detect. Each manager endeavors to achieve the organizational mission most economically, and effectively. The improvements in working conditions, will increase productivity and improve employer- employee relations. Workers have to spend less time thinking of their own safety. Experience has shown that an employee will works much faster in a safe, compatible environment than in one in which he or she feels endangered. Top executive managers often create safety problems for middle managers. Top executives often make a decision and then tell middle managers to get it done. The result is often increased production at unsafe rates of work or supervision, or reduction in expenditures for necessary safety equipment. A prime requisite for any successful accident prevention program is to leave no doubt in the mind of employees that supervisors are concerned about their safety. Supervisors such as low-level managers and foremen have close contact with workers and can provide the closest control of all activities, including save operations. Similarly, the supervisor is often at the receiving end when there are recriminations schedules to carry out that they are often over worked, and certain duties are not accomplished adequately. Although it is frequently and truly said that safety is everyone's responsibility. Sometimes, when safety is everybody's business, it becomes nobody's business. The supervisor, manager or foreperson is key to ensuring that this does not happen.

2.33 Management & Supervision:

The manager responsible for any operation can have an effective program is to:

1. Provide a coordination effort, integrating the safety efforts of all organizations concerned.

2. Direct the participation of all subordinate organization heads in the safety effort, with specific responsibilities assigned to each.
3. Establish in writing and disseminate specific and firm safety policies for the organization, and then ensure they are carried out.
4. Establish a safety elements that reports directly to the manager to be sure the safety program is carried out properly and effectively.
5. Carry out safety training on a continuing basis for all supervisors and workers, especially those newly employed or transferred. no supervisor should assume that any new employee has received adequate safety training but should check individual's knowledge and work habits.
6. Ensure:
   a. Good housekeeping practices are maintained at all times
   b. Every piece of plant, vehicle, or other item of equipment is operated with the limitations for which it was designed.
   c. New equipment is inspected on receipt to ensure that all desirable safety features and devices have been incorporated or provided.
   d. Access to equipment components during operation, maintenance, repair, or adjustment should not expose personnel to hazards.
   e. Persons involved in any hazardous operation should be instructed to report promptly any unusual condition or malfunction.
7. Check that every reported dangerous conditions or accident is investigated.
8. Provide budgets adequate for achievement of all safety objectives.

2.34 Actions Taken To Enhance Safety Level:

1. Housekeeping: by cleaning the work place from the oil leaks & spillage or Scraps
2. To enhance the individual safety action plans ISAP's: by Reviewing, Updating& Implementations the individual safety action plans.
3. Outside Contractor: to follow up, warning & reporting any violations that results from outside contractors.
4. Reducing the hazards: to prevent oil Leaks & spillage, to Secure Rotating elements, and to check the proper uses of ladders, handrails & scaffolds.
5. Taproot investigations: to follow up of cases and the Implementation of corrective actions.
6. Training safety issues: to train 14 days labors & encouraging reporting near miss accidents.

7. Encourage the safety meetings.

8. Following up the existing program of preventive maintenance of periodic checking of equipments and machine before any failure occurs.

2.35 APC Natural Resources:

Consideration is given to the availability of natural resources such as water and energy that can influence the performance of APC. While such resources are often out of the direct control of the APC, they can have significant positive or negative effects on its results, APC have plans to ensure the availability of these resources in order to prevent or minimize negative effects on the performance of the organization.

2.36 The Role Of The HR/Personnel Department:

An organization is a large group of persons united to achieve any task. It may also be defined as pooling of human physical and spiritual resources in order to achieve any predetermined task. An organization is generally - depending on its size and the scope of its activities - divided into a number of departments (and some of those may be further divided into sections. Organization structure deals with the overall organizational arrangements in an enterprise. A clear understanding of organization structure is helpful in making more frequent detailed adjustments in organizational arrangements.

Some of the departments will be concerned directly with the primary functions' of the organization, such as production and sales. Other departments provide 'services' which assist the smooth and efficient running of the primary functions. As we have already seen, one such 'service department' is the HR/personnel department which, under the control of the HR/personnel manager, provides a range of services to:

1. Other departments and their managers.
2. To the employees of the organization (and directly or indirectly to their families as well.
3. To the organization as a whole:

   Although the HR/personnel department is generally considered to be nonproductive, the standard of quality and efficiency of the services which it provides can be vital to the smooth functioning and prosperity of the entire organization.

2.37 The HR/Personnel Policy:

Policies are plans in that they are general statements or understandings which guide or channel taking and action in decision making. Once can hardly refer to all policies as "statements," since they are

often merely implied from the actions of managers. Policy-making is a key component of the total planning activity of any organization. A policy is an expression by the top management of an organization's of its values and beliefs concerning all the major functions of that organization. A policy states how the organization intends to approach the achievement of its overall objectives[3,31] . If an HR/personnel department is to succeed in its aims and to benefit the organization and its workforce as a whole, it is necessary for it to operate in accordance with an HR/personnel policy formulated by the governing body of the organization. Such a policy should be laid down after consultations with:

1. The HR/personnel manager and/or his or her senior subordinates (such as the industrial relations officer.
2. If necessary with representatives of trade unions or other staff bodies (such as staff associations or works councils); and should.
3. Take account of the attitudes of such bodies, as well as current government policies, legislation, regulations and directives.

An HR/personnel policy should comprise a set of principles which will:
"Govern the relationship of the organization with its workforce, whatever the status of individual members of it."
The policy must:
(i) Be absolutely clear and unambiguous;
(ii) Be easily understood by ALL;
(iii) And its effects on individual employees must be standardized.

Many factors contribute to good management/worker and good industrial relations but fairness, justness and equality of treatment to all are the basic ingredients.

The HR/personnel policy formulated should concentrate on two aspects: -

1. Those activities which can be governed by clearly laid down procedures which are to be followed as and when circumstances require; procedures will be set to cover such matters as the recruitment, selection, promotion and training of employees.
2. Those activities which are aimed at creating and maintaining a good "work climate" and contented workers.

The creation of suitable procedures for the first group of activities is a relatively straightforward matter, and most trained and experienced managers can deal well with what is involved. However, one need only to read or hear about the frequent industrial disputes and strikes which take place to realize that in many cases management has failed to act correctly with the second group of activities the "human" factors. This is often due to a negative approach or disinterest; to following old-fashioned or out-dated policies and attitudes instead of the modern, caring, understanding, participative approach required for harmony.

2.38 Management Versus The Workers:

Exactly the opposite situation to that which modern management must seek to achieve. Whilst outmoded attitudes are allowed to exist in an organization, maximum efficiency will never be attained as there will be no co-ordination of effort to achieve a common objective. The following are examples of matters which might be covered in contemporary HR/personnel policies:

1. Every employee regardless of sex, age or creed shall have equal opportunities for promotion and advancement.
2. All employees will be encouraged to participate in training and development activities of mutual benefit to the individual and to the organization.
3. Every employee shall have the right to fair treatment in matters concerning discipline.
4. The organization will negotiate only with recognized trade unions, and will always negotiate if good faith with trade union representatives.

Policies such as those we have given as examples are intended to express the long-term view of how the organization concerned intends to conduct its "personnel relations". Once such rules of behaviors have been set down, whether in written form or through custom and practice, it is possible to develop strategies which are consistent with them.

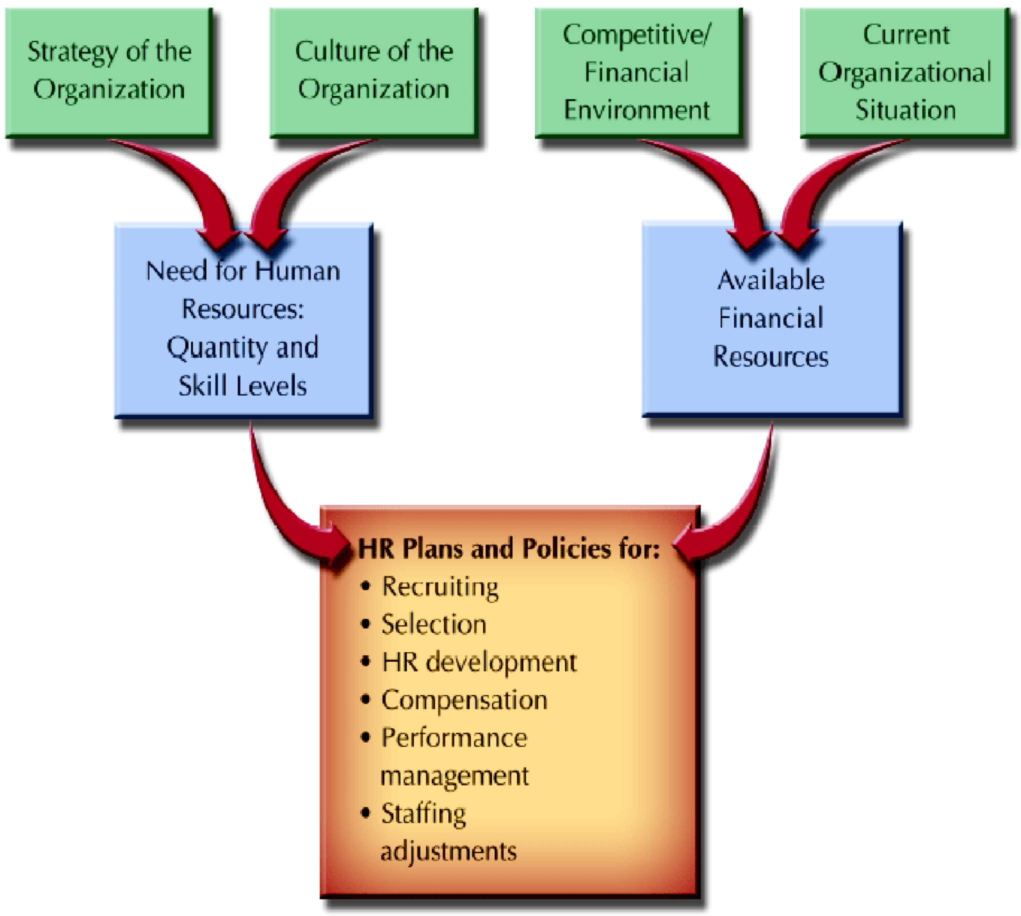
2.39 HR/Personnel Policy & Strategy:

Unlike a policy, a strategy is statement of: *"Long-term objectives to be achieved."* Strategic objectives focus on "ends" rather than on "means", and are commonly set for some years- say five - ahead. They are intended to provide a "framework" within which detailed operational plans can be made. Ideally strategies should be "measurable" - but only in general terms; if they are capable of being expressed in detailed terms, they are not strategic but operational or short-term objectives to be achieved.

Its senior management team will set strategic objectives for all the major functions of an organization. HR/personnel management strategies are therefore the result of discussion and agreement between all the senior managers of the organization and not just between the HR/ personnel specialists. It is to be expected that the first objectives to emerge will be those which relate to the organization's principal activities.

2.40 Factors That Determine HR Plans:

Fig. (2.15) Factors that determine HR plans.



2.41 Human Resource Planning:

The planning function has four important goals: to offset uncertainty and change, to focus attention on objectives, to gain economical operation, and facilitate control.

1) Human Resource (HR) Planning:

The process of analyzing and identifying the need for and availability of human resources so that the organization can meet its objectives.

2) HR Planning Responsibilities:

Top HR executive and subordinates gather information from other managers to use in the development of HR projections for top management to use in strategic planning and setting organizational goals.

2.42 HR Planning Process:

Fig.(2.16) HR Planning Process

2.43 Operating Plans:

Operating plans set out detailed statements relating to how the organization intends to actually achieve its strategic objectives in practice. Such plans are as much concerned with "means" as with short-term aims. They are intended to prompt the actions that are required for "theory" and intentions to be put into actual practice. Goals and objectives have basically the same meaning. However, it is possible to differentiate between the two by using goals for long –term planning and objectives for short- term planning. Goals must be based on statistical evidence. Without statistical knowledge of the system, goals merely reflect the assumption that slogans, exhortations, and hard work will miraculously change the system. Goals must be definitive, specific, and understandable [7].

2.44 Benefits Of HR Planning:

1. Better view of the HR dimensions of business decisions
2. Lower HR costs through better HR management.
3. More timely recruitment for anticipate HR needs

4. More inclusion of protected groups through planned Increases in workforce diversity.
5. Better development of managerial talent.

2.45 Effects Of A Good HR/Personnel Policy:

All these efforts to promote a good 'work climate' can be expensive to finance, but the benefits derived from such enlightened management could be well worthwhile. They are designed to act as "safety valves" to release pent-up pressures and frustrations which otherwise might simmer on beneath the surface, only to boil up and erupt at some future date into large-scale disputes. Therefore, it can be said that the formulation and pursuance of a comprehensive and farseeing HR/personnel policy can, both in the short-term as well as in the long-term, lead to greater understanding throughout the organization.

2.46 Responsibilities Of HR/Personnel Management:

HR/personnel management is that field of management which is concerned with the people who are employed by who work for an organization, and with their activities and relationships within that organization. Its primary function is two fold:

1. To bring together all those employed, whatever their status, sex, race or creed, and without whose joint efforts the organization could not prosper or indeed survive; and, whilst having regard to the individual and to work groups.
2. To foster their united interest in the success of the organization.

   That is no easy task bearing in mind the huge variety of differing characters, temperaments, needs, outlooks, opinions to say nothing of political persuasions of the many individuals who might work for a particular organization. And the larger the organization, the greater is the task of developing unity and harmony likely to be. Nevertheless it must be attempted, and attempted well; and the importance of the HR/personnel manager and of his or her department must never be underrated.

2.47 Employment Section:

This section will be responsible for maintaining an adequate labors supply. It will be in direct contact with each worker when he or she is selected and placed in his or her job. Other contacts will be made during induction and the "follow up" to ensure that the original placing was correct. It will also be concerned with transfers and with the retirement of employees, and in addition it will keep all records of employees (other than those, perhaps, of the top executives.) Selection and Placement:

2.48 Selection:

a. The process of choosing individuals who have needed qualities to fill jobs in an organization.

b. Organizations need qualified employees to succeed.

2.49 HR's Role In Selection & Placement:

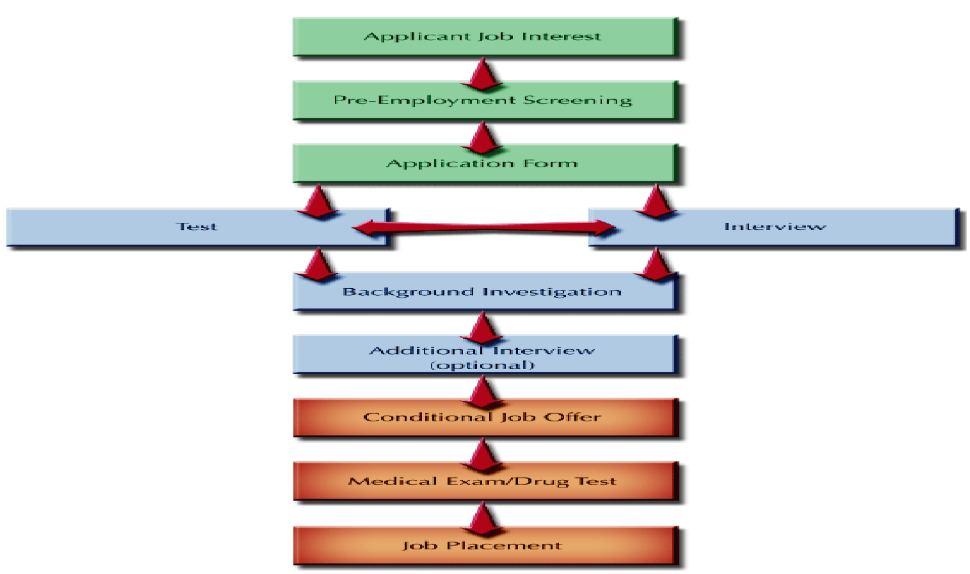
a. Reasons for centralizing selection:

1. Easier to have applicants in one place.
2. Contact with outside applicants is easier.
3. Managers can concentrate on operating
4. Responsibilities rather than the selection process.
5. Selection costs are lower with no duplicated efforts.

b. HR Employment Functions:

1. Receiving applications
2. Interviewing applicants
3. Administering tests to applicants
4. Conducting background investigations
5. Arranging physical examinations
6. Placing and assigning new employees
7. Coordinating follow-up of new employees
8. Exit interviewing departing employees
9. Maintaining employee records and reports.

Selection Process Flow Charts see fig.(2.17)



2.50 Promotion Section:

This section is usually a part of the employment section and is responsible for maintaining records and assessing the general suitability of people for promotion. Recommendations will normally be made through heads of departments to the HR/personnel promotion section, which will take the necessary action or make recommendations to higher levels.

2.51 Training, Education and Employee Development Section:

Training: a process whereby people acquire capabilities to aid in the achievement of organizational goals.

A. Training makes organizations more competitive

B. Training helps retain valuable employees

C. Training is no longer the first casualty of a business downturn.

As its title suggests, this section has a dual role:

1. It must arrange for the training of all newcomers in the performance of their jobs; that might involve the establishment of special training schemes within the organization itself.
2. It has the responsibility of ensuring that training and education and employee development in the wider sense are not neglected, especially of young employees; that will involve decisions on the correct type of educational or training courses which the employees should undertake, the negotiating of day release or sandwich courses or evening classes with technical colleges, and other “outside” educational or learning centers, arranging correspondence courses or distance learning programs, or other appropriate methods of tuition.

2.52 Medical Section:

The responsibility of this section is to maintain the health of the workers. In collaboration with medical practitioners and by employing trained staff, there will not only be an initial and periodic examination of employees, but treatment will be available for all minor injuries suffered whilst at work, as well as facilities for removal to hospital in the case of major accidents. The value of this section might not be immediately obvious to you, but it has advantages to both employees and employers:

1. Under a good medical scheme workers will be well taken care of and their health will be maintained; they can be sure that their health will not suffer by virtue of their employment.
2. The employer gains from such a scheme as it reduces the “man-hours” lost. There is less risk of infection if a minor injury receives skilled medical treatment at once, and the risks of the worker going absent

due to the injury are greatly reduced. One of the greatest causes of lost man-hours is injury at work, and is a serious drawback to any organization.

2.53 Staff Welfare Section:

This section is closely related to, and is often part of, the medical section. It can usually be divided into two divisions:

1. The Safety Division whose work is carried out in close co-operation with all sections of the organization. The aim of this division is to locate areas of danger, and to eliminate them and to be constantly seeking improved safety measures and safety practices as they relate to the activities of the organization. Many larger enterprises employ safety officers to keep a check on all aspects of employee protection and to ensure that the accident rate at work is as low as possible.
2. The Employee Services Division is concerned with such matters as canteen facilities, social and recreational activities, and such matters as holidays, sports and legal facilities, etc. The extent to which an organization can provide employee services depends upon its size and financial resources.

2.54 Communication:

Definition of communication: Effective and rapid communication is vital tool of modern management, it can be defined as:

1. The passage or conveying of a message or an idea from one party to another in such a fashion that both parties perceive its identical meaning.
2. Communication: is the process whereby speech, signs or actions transmit information from one person to another. This definition is concise and definitive but doesn't include all the aspects of communication. There are other definitions, which state that communication involves transmitting information from one party to another. This broader definition doesn't require that the receiving party obtain a full understanding of the message. Of course, communication is better when both parties understand but it can still exist even without that component [4]. No matter the type or mechanism of communication, every instance of communication must have a message that is being transferred from sender to receiver. In order for communication to be successful, the sender and receiver must have some signs, words or signals in common with each other so the sent message can be understood. The ideal definition of communication is a 2 way interaction between two parties to transmit information and mutual understanding between themselves. The interchange of information from one party to another is best communicated when a

discussion is available so the receiver can ask questions and receive answers to clarify the message. Without communication, nothing could happen within an organization no information or instructions could be given or received, there could be no contact between members of management or between them and their subordinates, and no contact with customers or suppliers.

2.55 Man Power Planning, Job Analysis & Job Description

In small to medium size organization, the directors (and the owners of the shares of a company) might also act as full time departmental manager and, indeed, each might control more than one department or section of the organization. In the early stages of the development of an organization such an arrangement might be very economical, in the sense that costly salaried managerial personnel are not required, and it can also be more efficient because each director will have a "vested interest" in the success of the organization. Problems that might arise from time to time can usually be quickly solved, because that director who is office manager in his capacity as HR/ personnel manager – is likely to be readily available and accessible, and so able to deal with an employee's complaint or request for advice within a matter of hours, or even in minutes.

2.56 HR Or Manpower Planning:

The fairly complex activity of "HR plans or manpower planning" can be summarized as being: "A strategy for the acquisition, utilization, improvement and retention of an organization's human resource." In practice, the activity is concerned with forecasting and estimating – in fact "identifying" – the future demand for labours by an organization, and with laying down polices and plans to ensure that, as far as is possible and feasible, the correct number of each grade of personnel is available and trained when needed. It is thus directed specifically at the current and future size and composition of a workforce. it is concerned with:

1. The recruitment and training of adequate and suitable employees.
2. Their retention in the employ of the organization.
3. The optimum most effective utilization of the workforce.
4. The improvement of employee performance.
5. The disengagement of employees if necessary. HR or manpower planning is therefore the process of identifying the organization form and skills base necessary to achieve the corporate plan of the organization, in respect of:

a. The structure of the each department function.

b. The skills and experience needed.

c. The number of people required to carry out all the duties and responsibilities involved.

Although labours statistics are an important element, HR or manpower planning must be considered. The quality of the workforce and with its deployment throughout the organization. There are four categories of employee which are important in HR/ manpower planning, and each requires different decisions to be made about them, as detailed in the following table (2.8.

Table (2.8) The Categories of employee & the decisions to be made about them.

Category	Decision need to be taken with regard to
Existing employees	Performance appraisal, Productivity, Deployment, Equal opportunities, Education and training, Remuneration, Promotion and career development
New recruits	Recruitment sources and methods, Selection procedures, Terms of employment, Induction, On the job and additional training
Potential employees	Recruitment sources and methods, Public relations, Remuneration levels, Employee benefits packages
Leavers	Dismissal for inadequate performance, Retirements, Redundancy procedures/labour turnover

The first step in HR/ manpower planning requires an investigation of all levels of the existing workforce, from the most junior employees to senior management. The results will show where and on what manpower is being used, whether there are much inefficiency in the way it is being utilized and the degree of skill needed by the various sectors of the workforce.

The following some of typical causes of manpower planning errors and problems:

1. Inadequate or unrealistic market intelligence.
2. Over-forecasting or under-forecasting of sales.
3. Underdeveloped organizational structure.
4. Overlapping or ill-defined job structures.
5. Inaccurate or unrealistic labour budgeting.
6. Empire –building or excessive cautiousness.

7. Lack of or inaccurate job standards.
8. Skill shortages in the employment market.
9. High labour turnover or wastage.
10. Ineffective recruitments and placement.
11. Ineffective labour management or supervision.
12. Industrial disputes and work stoppages.
13. High levels of sickness/ absence.

2.57 Job Analysis:

To define a job of work simply as a "collection of tasks assigned to a position or post in an organization' in practice, an individual employee's job is intimately involved with the " role" he or she is expected to perform in the job. Job analysis is the name given to the total process of examining and appraising jobs in order to identify their main features, specifically the duties they fulfil, the results they are expected to achieve, the major tasks undertaken, and their relationships with other jobs. During the analyses the facts concerning each job will be systematically recorded. Such " job facts" will include:

1. What different tasks are involved in the job as a whole?
2. How the tasks should be performed, i.e. the procedures involved in the best possible performance of each task or group of related tasks.
3. What qualification (education, training, experience, special skills, intelligence, etc.) and personal attributes (good eyesight, good hearing, a pleasant speaking voice, manual dexterity, etc) should ideally be processed if the various tasks are to be performed in the most satisfactory manner.
4. For what and or for whom the holder of the post will be responsible.

The information obtained about various jobs in section or department or an entire organization, will enable jobs to be compared and provide some indication of the status and worth of various jobs.

2.58 Job Descriptions:

A job description, as its name implies, describes, specifies or defines the particular job, and is embodied in a document which is prepared based on the information obtained from the relevant job analysis. As general rule, a job description usually states the purpose of the job and its relations with other jobs and people, lists the physical, social and economic features involved. Job description contains:

1. The current job title, the section / department in which the potholder will work, details of the work group or groups with whom the post holder will be involved.
2. A usually brief statement of the purpose of the job- its objectives.

3. A list of all the tasks and duties involved in the whole job.
4. Details of the responsibilities of the post holder, that is, for what and for whom he or she will be responsible.
5. Full details of salary or wage rates, overtime rates, bonuses, commission and fringe benefits, such as car or transport allowance .
6. Fact about the environment in which the post holder will work.
7. Details of such matters as hours of work, overtime, unsocial hours, holidays, sick leave.

Chapter Three:
Activities Planning & Management Of The Case Study

3.1 Project Management In General:

Project management involves the coordination of group activity wherein the manager plans, staffs, directs, and controls to achieve an objective with constraints on time, cost, and performance of the end product. The project manager is the person responsible for accomplishing the project objectives.

Managing a project includes:

i. Identifying requirements

ii. Establishing clear and achievable objectives

iii. Balancing the competing demands for quality, scope, time and cost

iv. Adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders.

High quality projects deliver the required product, service or result within scope, on time, and within budget. The relationship among these factors is such that if any one of these factors changes, at least one other factor is likely to be affected. The project management team has a professional responsibility to its stakeholders including customers, the performing organization, and the public.

What does the customer want to know?

1. Do you understand my needs?
2. Can you design a system to help me?
3. How long will it take?
4. How much will it cost?

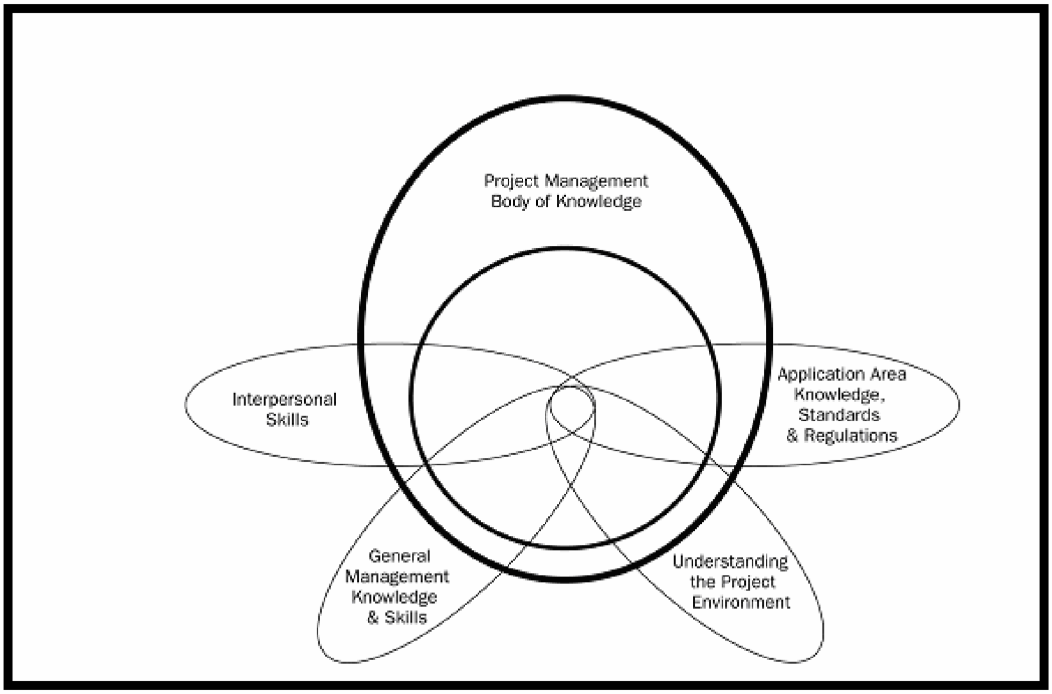
It is important to note that many of the processes within project management are iterative because of the existence of, and necessity for, progressive elaboration in a project throughout the project's life cycle.

That is, as a project management team learns more about a project, the team can then manage to a greater level of detail. The term "project management" is sometimes used to describe an organizational or managerial approach to the management of projects and some ongoing operations, which can be redefined as projects that is also referred to as "management by projects." Managing is essential in all organized corporation, as well as at all levels of organization in an enterprise.

3.2 Project Management Body Of Knowledge

The Project Management Body of Knowledge describes knowledge unique to the project management field and that overlaps other management disciplines. Fig.(3.1) shows the common areas of expertise needed by the project team.

Fig.(3.1. Areas of Expertise Needed by the Project Team



3.3 Project Life Cycle & Organization:

Projects and project management are carried out in an environment broader than that of the project itself. The project management team must understand this broader context so it can select the life cycle phases, processes, and tools and techniques that appropriately fit the project.. The topics included here are:

1. The Project Life Cycle
2. Project Stakeholders
3. Organizational Influences

3.3.1 The Project Life Cycle:

Project managers or the organization can divide projects into phases to provide better management control with appropriate links to the ongoing operations of the performing organization. Collectively, these phases are known as the project life cycle. Many organizations identify a specific set of life cycles for use on all of their projects [1].

3.3.2 Characteristics Of The Project Life Cycle:

The project life cycle defines the phases that connect the beginning of a project to its end. The phases of a project life cycle are not the same as the Project Management Process The transition from one phase to another within a project's life cycle generally involves, and is usually defined by, some form of technical transfer or handoff. Deliverables from one phase

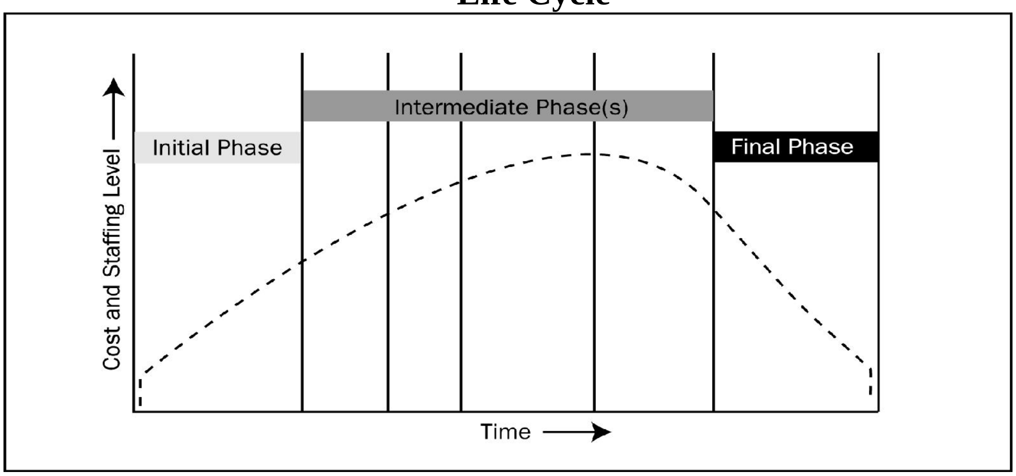
are usually reviewed for completeness and accuracy and approved before work starts on the next phase. However, it is not uncommon for a phase to begin prior to the approval of the previous phase's deliverables, when the risks involved are deemed acceptable. This practice of overlapping phases, normally done in sequence, is an example of the application of the schedule compression technique called fast tracking. There is no single best way to define an ideal project life cycle. Project life cycles generally define:

a. What technical work to do in each phase
b. When the deliverables are to be generated in each phase and how each deliverable is reviewed, verified, and validated.
c. Who is involved in each phase .
d. How to control and approve each phase.

Project life cycle descriptions can be very general or very detailed. Highly detailed descriptions of life cycles can include forms, charts, and checklists to provide structure and control. Most project life cycles share a number of common characteristics:

i. Phases are generally sequential and are usually defined by some form of technical information transfer or technical component handoff.
ii. Cost and staffing levels are low at the start, peak during the intermediate phases, and drop rapidly as the project draws to a conclusion. Fig.(3.2) illustrates this pattern.

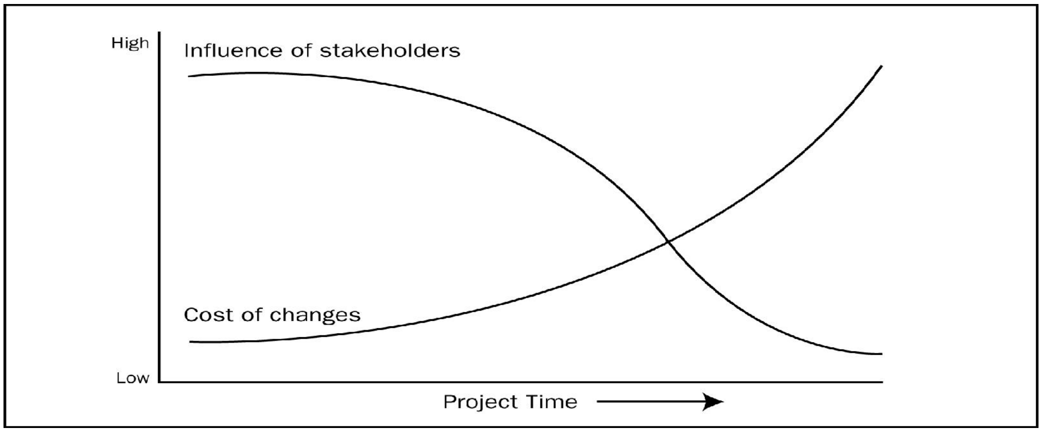
Fig. (3.2. Typical Project Cost and Staffing Level Across the Project Life Cycle



iii. The level of uncertainty is highest and, hence, risk of failing to achieve the objectives is greatest at the start of the project. The certainty of completion generally gets progressively better as the project continues.
iv. The ability of the stakeholders to influence the final characteristics of the project's product and the final cost of the project is highest at the

start, and gets progressively lower as the project continues. Figure (3.3) illustrates this. A major contributor to this phenomenon is that the cost of changes and correcting errors generally increases as the project continues.

Fig. (3.3) Stakeholders' Influence Over Time



Although many project life cycles have similar phase names with similar deliverables, few life cycles are identical. Some can have four or five phases, but others may have nine or more. Single application areas are known to have significant variations.

3.4 Project Time Management:

Project Time Management includes the processes required to accomplish timely completion of the project. Fig.(3.4) provides an overview of the Project Time Management processes and Fig.(3.5) provides a process flow diagram of those processes and their inputs, outputs, and other related Knowledge Area processes. The Project Time Management processes include the following:

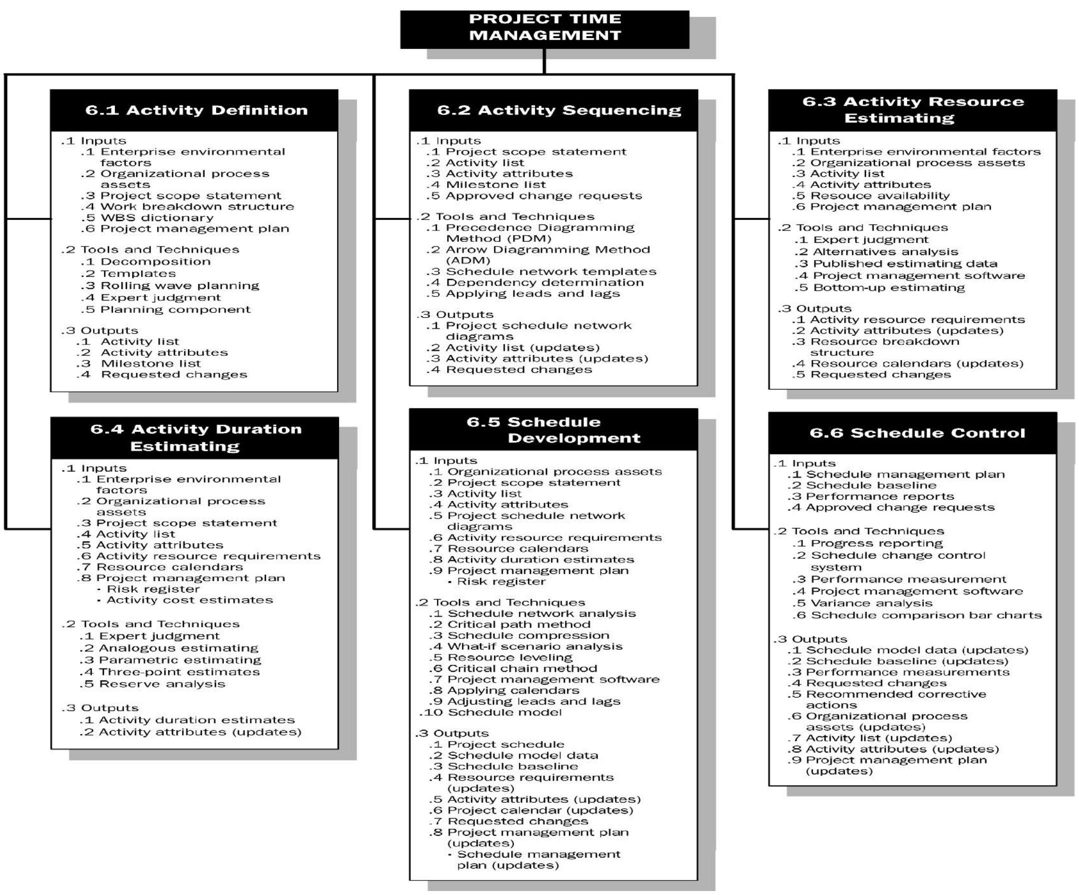
1. Activity Definition identifying the specific schedule activities that need to be performed to produce the various project deliverables.
2. Activity Sequencing identifying and documenting dependencies among schedule activities.
3. Activity Resource Estimating the type and quantities of resources required to perform each schedule activity.
4. Activity duration estimating the number of work periods that will be needed to complete individual schedule activities.
5. Schedule development analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.
6. Schedule controlling changes to the project schedule.

These processes interact with each other and with processes in the other Knowledge Areas as well. Each process can involve effort from one

or more persons or groups of persons, based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete components with well-defined interfaces, in practice they can overlap and interact in ways not detailed here.

On some projects, especially ones of smaller scope, activity sequencing, activity resource estimating, activity duration estimating, and schedule development are so tightly linked that they are viewed as a single process that can be performed by a person over a relatively short period of time. These processes are presented here as distinct processes because the tools and techniques for each are different. The project time management processes, and their associated tools and techniques, vary by application area, are usually defined as part of the project life cycle, and are documented in the schedule management plan.

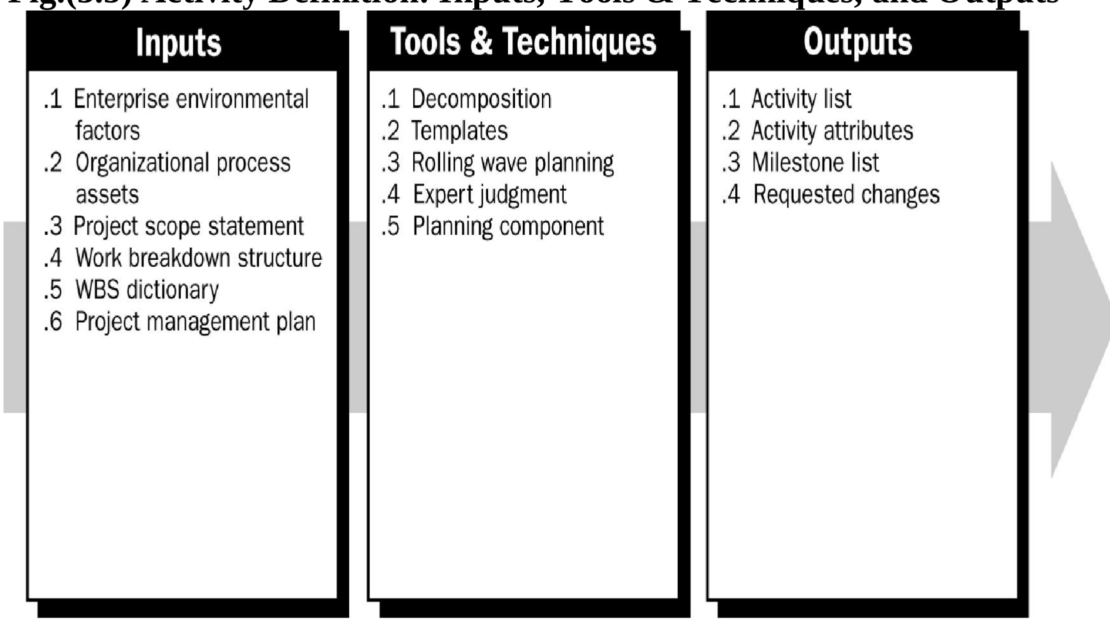
Fig.(3.4) Project Time Management Overview



3.5 Activity Definition:

Defining the schedule activities involves identifying and documenting the work that is planned to be performed. The Activity Definition process will identify the deliverables at the lowest level in the work breakdown structure (WBS), which is called the work package. Project work packages are planned (decomposed) into smaller components called schedule activities to provide a basis for estimating, scheduling, executing, and monitoring and controlling the project work. Implicit in this process is defining and planning the schedule activities such that the project objectives will be met.

Fig.(3.5) Activity Definition: Inputs, Tools & Techniques, and Outputs



3.6 Activity Sequencing:

Activity sequencing involves identifying and documenting the logical relationships among schedule activities. Schedule activities can be logically sequenced with proper precedence relationships, as well as leads and lags to support later development of a realistic and achievable project schedule. Sequencing can be performed by using project management software or by using manual techniques. Manual and automated techniques can also be used in combination.

3.7 Development Of The Network Plan Concept:

The network diagram is essentially an outgrowth of the bar chart which was developed by Gantt in the context of the World War I military requirement. The bar chart, which is primarily designed to control the time

element of a program [1, 20]. Here, the bar chart lists the major activities comprising a hypothetical project, their scheduled start and finish times, and their current status.

The steps followed in preparing a bar chart are as follows:

1. Analyze the project and specify the basic approach to be used.
2. Break the project down into a reasonable number of activities to be scheduled.
3. Estimate the time required to perform each activity.
4. Place the activities in sequence of time, taking into account the requirements that certain activities must be performed sequentially while others can be performed simultaneously.
5. If a completion date is specified, the diagram is adjusted until this constraint is satisfied.

The primary advantages of the bar chart are that the plan, schedule, and the progress of the project can all be portrayed graphically together.

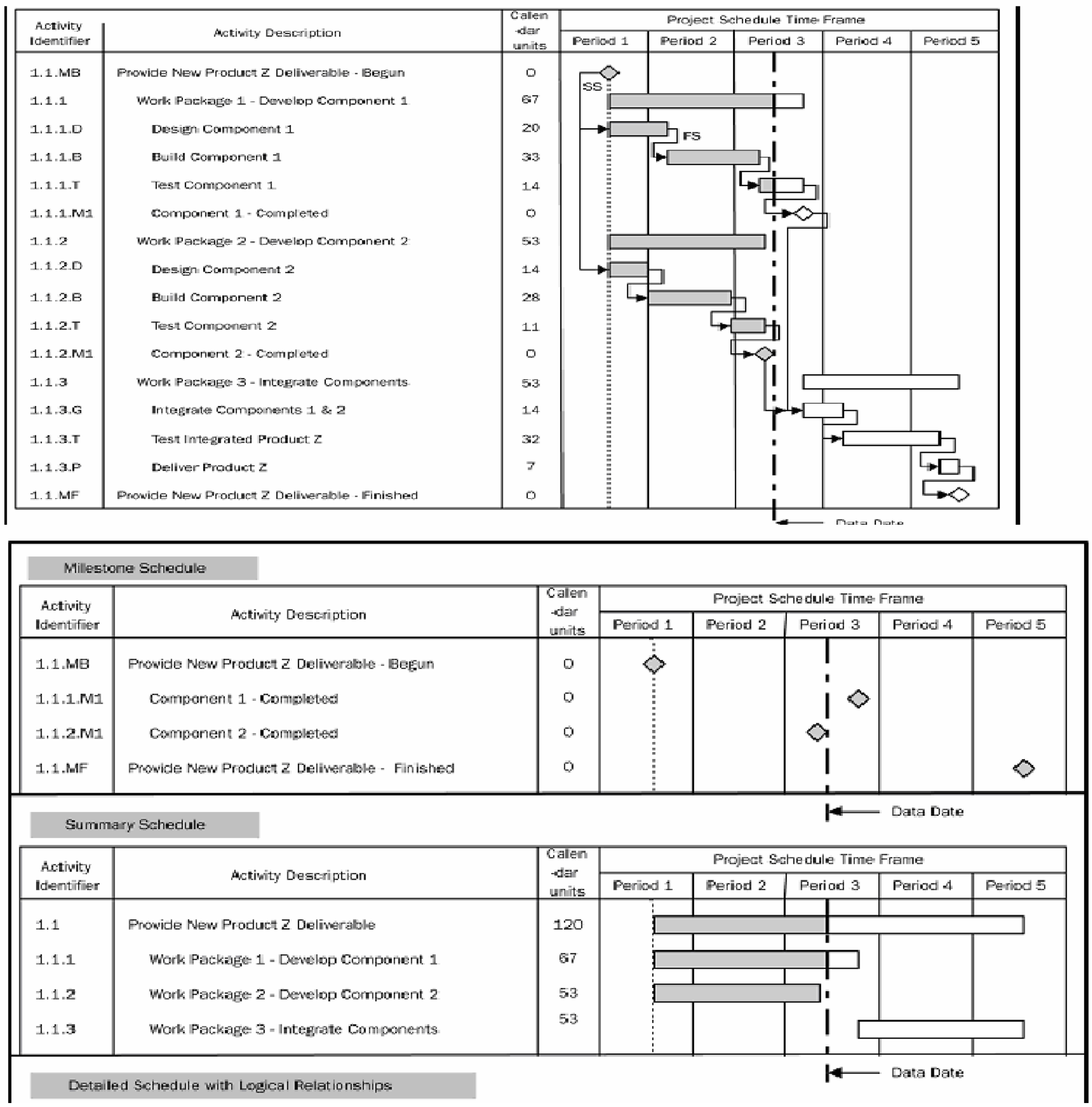
In spite of this important advantage, bar chart have not been too successful on one- time through projects with a high engineering content, or projects of large scope.

The reasons for this include the following:

1. Planning and scheduling are considered simultaneously.
2. The simplicity of the bar chart precludes showing sufficient detail to enable timely detection of schedule slippages on activities with relatively long duration times.
3. The bar chart does not show explicitly the dependency relationships among the activities. Hence, it is very difficult to impute the effects on project completion of progress delays in individual activities.
4. The bar chart is essentially a manual- graphical procedure. It is awkward to set up and maintain for large projects, and it has a tendency to quickly become outdated and lose its usefulness.

Fig.(3.6) shows the schedule for a sample project being executed, with the work in progress reported through the data date, which is sometimes also called the as-of date or time now date. The figure shows the actual start date, actual duration, and actual finish date for completed schedule activities, the actual start date, remaining duration, and current finish date for schedule activities with work in progress, and the current start date, original duration, and current finish date for schedule activities where work has not yet started. Fig.(3.6) also visually shows the relationships among the three different levels of schedule presentation.

Fig.(3.6) Project Schedule – Graphic Examples



3.8 Project Scheduling, CPM:

Critical path method:- Is a management and scheduling technique which requires the construction manager plan and schedule in logical sequence the many detailed act required by specifications and plans to properly build structure in shortest time at least cost with minimum confusion.[1,3,20,]

Activity: is a job takes resources (money, material, etc.) and time. →

Events: is a point in time indicates the start and end of activity ○.

Dummy activity: - Job or tasks that does not consume resources or time. ------>.

Network: Is a diagram showing all activity.

Duration: Is a time required to perform an activity (months, weeks, hours, years, etc.)
Work break down structure: Dividing the large elements of the project to small activities.
Early start (ES): Is the earliest time when an activity can be started.
Early finish (EF): Is the earliest time when an activity can be finished.
Late start (LS): Is the latest time that an activity can be started without delay.
Late finish (LF): Is the latest time that an activity can be finished without delay.
Float: Is the spare time available to activities for critical path = 0, non critical > 0.
Critical path: The largest path from the project start to finish (is the minimum required. And has the least amount of float = 0.
Forward pass: Is used to determine the earliest finish time of various activity.
Backward pass: Is used to determine the latest finish and start time (LS, LF.
Basic calculation of network:
1. List all activities.
2. Decide logical sequence.
3. Assign duration.
4. Calculate ES, EF, LS, L.
5. Mark the critical path.

The initial project is assumed to accomplish at zero time. Assume that activities start as soon as possible that their proceeded act are computed.
Activity under study ij .
ES_{ij} = max of EF of act immediately.
The early finish of an activity is the sum of ES and duration.
$EF_{ij} = ES_{ij} + D_{ij}$. [1,20]
AON: Activity on node.
AOA: Activity on arrow.

3.9 Case Under Study No.1:

Table (3.1) The main activity duration and precedence for the case under study No.1

Activity description	Symbol	Time (day)	Precedents
Develop required material list	A	9	---------
Procure pipe	B	65	A
Erect Scaffold	C	13	----------
Remove scaffold	D	5	I,M
Deactivate line	E	9	-----------
Prefabricate sections	F	42	B
Place new pipes	G	34	F,L,J
Fit up pipe and valves	I	10	G,K
Procure valves	J	74	A
Place valves	K	10	J,L
Remove old pipe and valves	L	37	C,E
Insulate	M	26	G,K
Pressure test	N	8	I
Clean –up and start up	O	5	D,N

Fig.(3.7) Activity on arrow for the case study No1 which represent the overall network duration and connection.

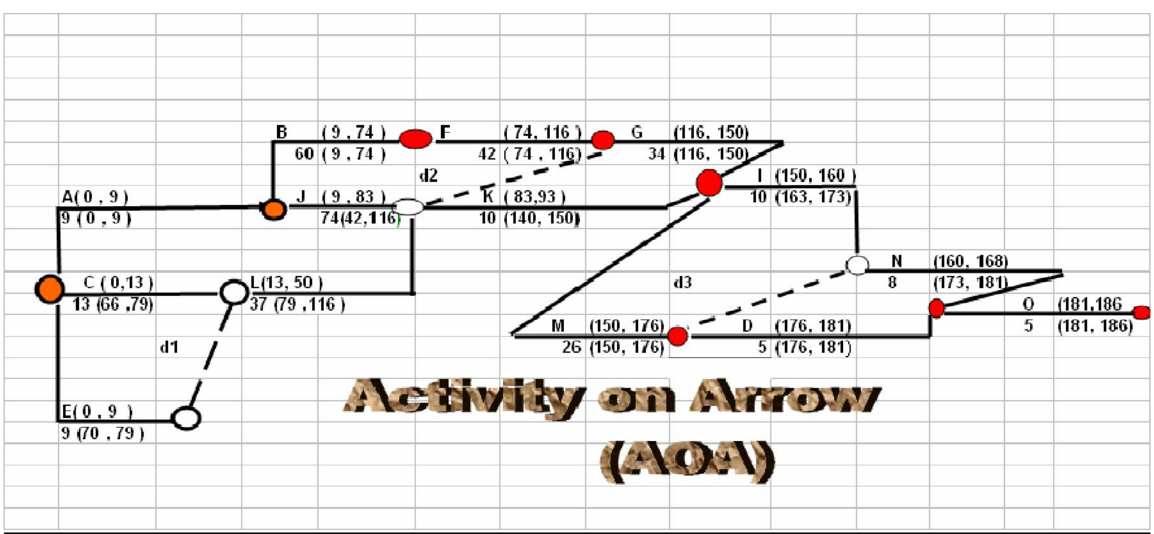
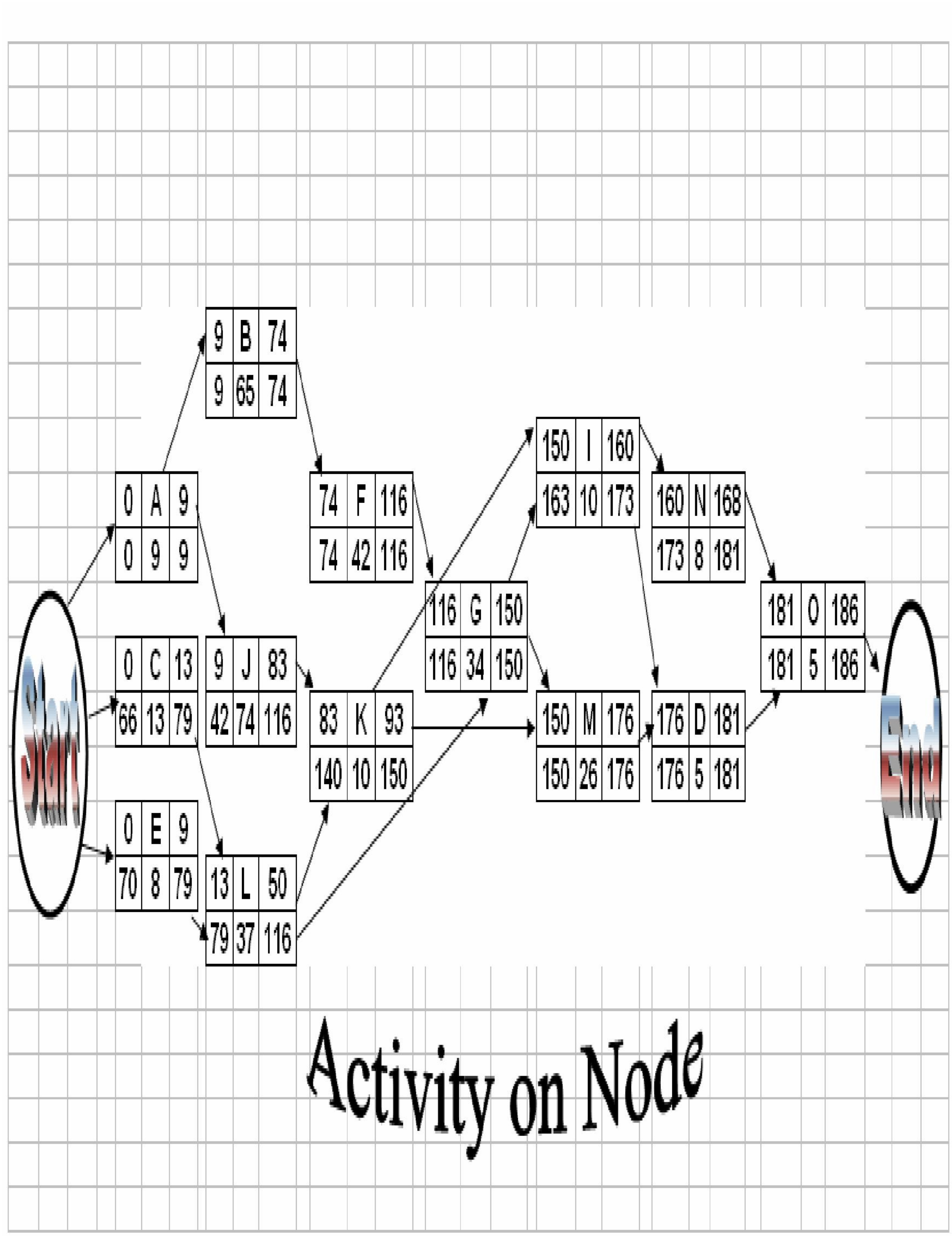


Fig.(3.8) Activity on Node for the case study No1 that represent the overall network connection.



Final Table (3.2) For the case under study No.1:

Activity	Duration	ES	EF	LS	LF
A	9	0	9	0	9
B	65	9	74	9	74
C	13	0	13	66	79
E	9	0	9	70	79
J	74	9	83	42	116
L	37	13	50	79	116
F	42	74	116	74	116
K	10	83	93	140	150
G	34	116	150	116	150
I	10	150	160	163	173
M	26	150	176	150	176
N	8	160	168	173	181
D	5	176	181	176	181
O	5	181	186	181	186

The critical baths:
[A-B-F-G-M-D-O]
The overall project duration = 186 day

3.10 Program Evaluation & Review Technique (PERT):

Plan activities and logic as in CPM and assign 3duration for each activity.

1. Optimistic completion time (a): Is the shortest time required to complete the activity assume everything will go according to plans.
2. Pessimistic completion time (b):Is the maximum time required to complete the activity assumes ever thing will not go according to the plans.

3. Most likely completion time (m): Is the time that would most often occur to complete the activity under normal condition.
4. The mean time (t_e):

$$(t_e) = \frac{(a + 4m + b)}{6} \qquad [20]$$

5. Variance = $\sigma t_e^2 = \frac{(b - a)^2}{36}$ [20]

Calculation Procedure:

i. Plan activities and logic as in CPM and assign 3duration for each activity.
ii. Translate the three estimates into continuous distribution and find the mean, standard deviation and variance.
iii. Use each t_e as duration and find the critical path.
iv. Combine the activities on the critical path to get a probability distribution for the critical path.
v. Make inference about the likelihood at the project beginning and completed on or at any given day.

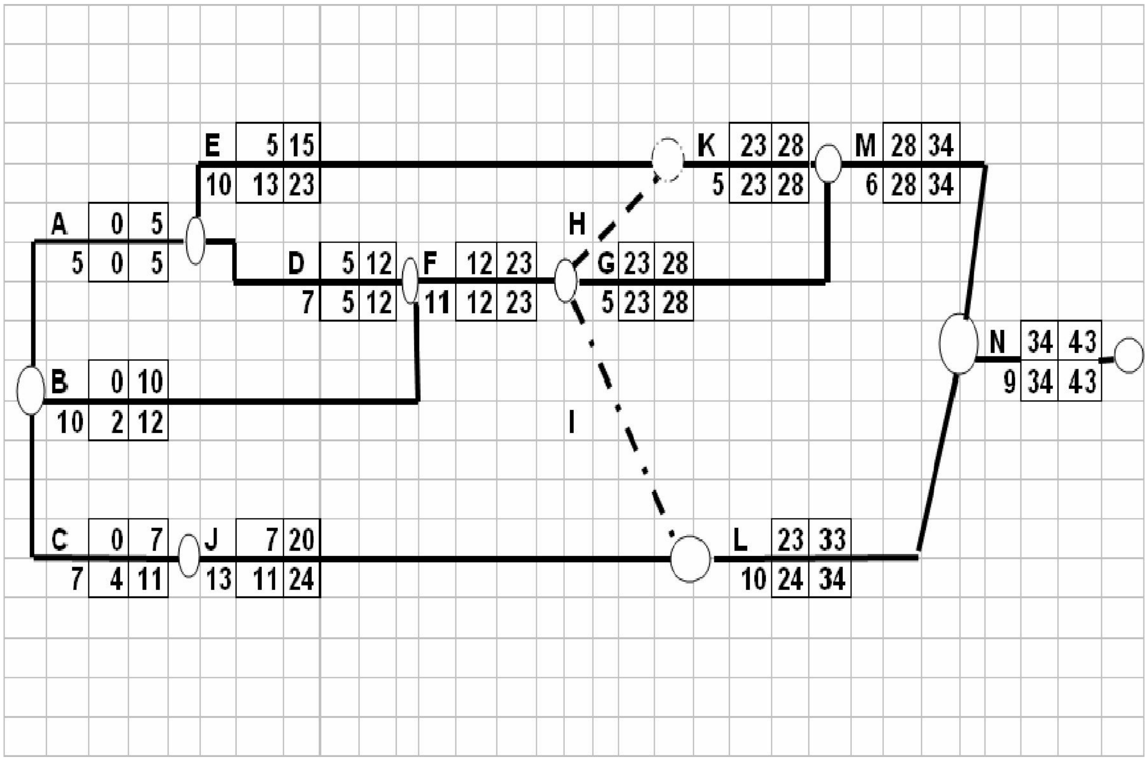
Case under study No. 2 for program evaluation and review technique see table (3.3).

Table (3.3) The main activity duration and precedence for the case under study No.2

Activity	IPA	(a) Optimistic time	(m) Pessimistic time	(b) Most likely time	t_e	V
A	-----	3	5	7	5	0.44
B	-----	9	9	15	10	1
C	-----	5	7	9	7	0.44
D	A	5	7	9	7	0.44
E	A	9	9	15	10	1
F	D,B	9	11	13	11	0.44
J	C	11	13	15	13	0.44
H	F	0	0	0	0	0
I	F	0	0	0	0	0
G	F	3	5	7	5	0.44
K	H,E	3	5	7	5	0.44
L	I,J	9	9	15	10	1
M	G,K	4	6	8	6	0.44
N	M,L	7	9	11	9	0.44

The following figures represent the critical path method for the case under study No.2.

Fig. (3.9) For the case under study No.2 the overall network



From the grave:
The project duration = 43day.
There is 2 critical path: -
Critical path No.1 = C1 [A-D-F-H-K-M-N]
Critical path No.2 = C2 [A-D-F-G-M-N]
For the critical path we find:-

Tables (3.4) The variance of the activities in each critical bath (No.1 & No.2)

C1	V1
A	0.44
D	0.44
F	0.44
H	0
K	0.44
M	0.44
N	0.44

C2	V2
A	0.44
D	0.44
F	0.44
G	0.44
M	0.44
N	0.44

$\sum V1 = 2.64$ & $\sum V2 = 2.64$
Б $t_e = 1.625$
$t_e = 43$

$$Z = \frac{t_s - t_e}{\text{Б}\, t_e}$$

Cases:-

1) Let $t_s = 43$

   Then Z = 0 from z table we find probability as follow:-

   P1 = 0.5   P2 = 0.5

   P_{joint} = P1 * P2 = 25%

2) Let $t_s = 40$

   Then Z = - 1.846

   P1 = 0.0328   P2 = 0.0328

   P_{joint} = P1 * P2 = 0.11 %

3) Let $t_s = 45$

   P1 = 0.8907   P2 = 0.8907

   P_{joint} = P1 * P2 = 79.3 %

3.11 Time Cost Trade Off:

The result of the planning and scheduling stages of the critical path method provide a network plan for the activities making up the project and a set of earliest and latest start and finish times for each activity. In particular, the earliest occurrence time for the network terminal events is the estimated " normal" project duration time, based on "normal" activity time estimates. The main purpose of this work can be stated as the development of a procedure to determine activity schedules to reduce the project duration time with a minimum increase in the project direct costs, by buying time along the critical path(s) where it can be obtained at least cost.

Crashing or least cost scheduling or time -cost trade off gives the same meaning.

Definitions:

1. Normal time: Is the time that assumes employment of the usual amount of labour, equipment.
2. Normal cost: Estimated expenses or performing the project within the normal time estimated.
3. Crash time: Minimum estimated time in which a job could be completed if the job accelerated by using one or more resources.
4. Crash cost: Normal cost plus the extra cost involved in applying overtime, extra labour, or addition equipment.

Note: Crashing done on critical path.

$$\text{Cost slope} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}} \qquad [20]$$

Assumptions:

Crash time is less than to normal time

Crash cost is greater than normal cost

The time / cost curve is generally linear
There is a minimum duration for any project beyond which further reduction is not feasible.
Determining optimum activities cost:

1. Prepare a table of activities on the critical path showing normal activity duration and cost.
2. Calculate slope in order of minimum cost slope
3. List the activities and delete the activities which cannot be compressed.
4. Compress the activities which minimum cost slope.
5. Calculate new project duration.
6. When minimum duration is reached, calculate indirect cost

Total cost = Direct cost + Indirect cost.
= New project cost

Table (3.5)Main activity duration and precedence for the case under study No.3

Activity	IPA	Normal duration	Crash duration	Normal cost	Crash cost	Slope
A	----	5	4	400	500	100
B	----	10	6	800	960	40
C	----	7	6	600	700	100
D	A	7	3	700	800	25
E	A	10	8	500	600	50
F	D,B	11	9	800	910	55
J	C	13	12	700	800	100
H	F	0	----	----	----	----
I	F	0	----	----	----	----
G	F	5	1	800	880	20
K	H,E	5	3	700	800	50
L	I,J	10	8	400	450	25
M	G,K	6	4	350	460	55
N	M,L	9	7	240	280	20

Over head cost = 80 JD / day.
From CPM we find the following table (3.6) :

Table (3.6) The CPM calculation for the Case under study No.3

Activity	ES	EF	LS	LF
A	0	5	0	5
B	0	10	2	12
C	0	7	4	11
D	5	12	5	12
E	5	15	13	23
F	12	23	12	23
J	7	20	11	24
H	-	-	-	-
I	-	-	-	-
G	23	28	23	28
K	23	28	23	28
L	23	33	24	34
M	28	34	28	34
N	34	43	34	43

Normal project duration = NPD
NPD = 43 day.
Direct Cost = DC
DC= Normal project cost
= 6990JD
Indirect Cost = IC
IC = Overhead x Normal duration
= 80 x 43
= 3440JD
Total cost = Direct cost + Indirect cost
TC = DC + IC
= 3440 + 6990
= 10, 430JD
For 43 day → TC = 10, 430JD
Cycle 1:-
The critical path: - Path (1)[A-D-F-K-M-N] & Path(2)[A-D-F-G - M – N]
For path (1) N with minimum slope = 20
For path (2) G with minimum slope = 20
N new duration will be: - 8 days
G new duration will be: - 4 days
Then we will calculate the new project duration:

Table (3.7) The CPM calculation for Cycle 1in the Case under study No.3

Activity	ES	EF	LS	LF
A	0	5	0	5
B	0	10	2	12
C	0	7	4	11
D	5	12	5	12
E	5	15	13	23
F	12	23	12	23
J	7	20	11	24
H	-	-	-	-
I	-	-	-	-
G	23	27	24	28
K	23	28	23	28
L	23	33	24	34
M	28	34	28	34
N	34	42	34	42

New Project Duration =NPD
NPD = 42 day.
New Project cost = 10430 + 20+ 20 -80
= 10390JD
For 42 days → TC = 10390 JD.
For cycle 2:
The critical path [A – D- F- K- M-N]
N with minimum slope then:
The new N duration = 7 days
Then we will calculate the new project duration table (3.8):
NPD = 41 days
NPC = 10330 JD.
We repeat the calculations and we find that for:-
Cycle 3 the critical path:-
[A- D-F-K-M-N]
Cycle 4 the critical path:-
[A-D-F-K-M-N
Cycle 5 the critical paths:-
[A-D-F-K-M-N] & [B-F-K-M-N]
Cycle 6 the critical paths:-
[A-D-F-K-M-N] & [B-F-K-M-N]
Cycle 7 the critical paths:-
[A-D-F-K-M-N], [B-F-K-M-N] & [C-J-L-N]
Cycle 8 the critical paths:-

[A-D-F-K-M-N], [A-D-F-G-M-N], [A-D-F-L-N] &[C-J-L-N]

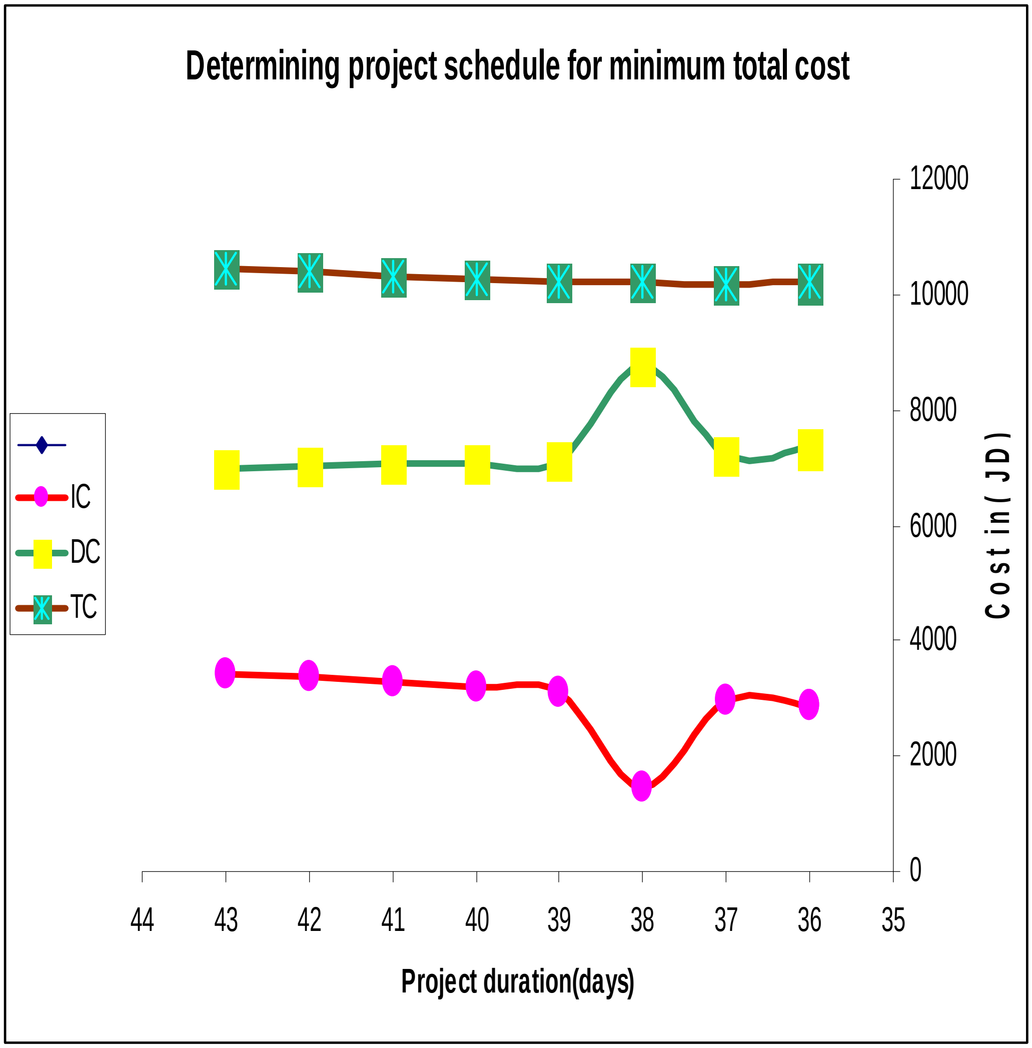
Table (3.8) The CPM calculation for Cycle2 in the Case under study No.3

Activity	ES	EF	LS	LF
A	0	5	0	5
B	0	10	2	12
C	0	7	4	11
D	5	12	5	12
E	5	15	13	23
F	12	23	12	23
J	7	20	11	24
H	-	-	-	-
I	-	-	-	-
G	23	27	24	28
K	23	28	23	28
L	23	33	24	34
M	28	34	28	34
N	34	41	34	41

Final Table (3.9) The Cost & time relation in the Case under study No.3.

Time(days)	Indirect cost (JD)	Direct cost (JD)	Total cost (JD)
36	2880	7310	10190
36	2880	7345	10225
37	2960	7230	10190
38	1444	8761	10205
39	3120	7100	10220
40	3200	7075	10275
41	3280	7050	10330
42	3360	7030	10390
43	3440	6990	10430

Fig.(3.10) Determining project schedule for minimum total cost



Thus from this calculation the project or activities duration time reduced from 43days to 37days which is about 13.95% with a minimum increase in the project direct costs from 6990JD to 7230 JD which is about 3.32%.

The purpose of these calculations:-

1- Avoid penalty 2- Earn bonus of project completion

3.12 Motion Study (Method Study):

In this field pioneering work was done by frank B. Gilbreth and his wife Lillian M. Gilbreth, around 1910, with the name of motion study. Frank Gilbreth. The real founder of motion study as the science of eliminating wastefulness resulting from ill –directed and efficient motions". the aim of motion study is to find the scheme of least wastage of labour.

Later on the scope of motion study was enlarged and it was named as method study [1, 2]. Method study is a technique which analyses each operation of a given piece of work, very closely in order to eliminate unnecessary operations and to approach the quickest and easiest method of performing each necessary operation; it includes the standardization of equipment, method and working conditions; and training of the operator to follow the standard method.

Some important aims of the motion study are:

1. To eliminate wastage of time and labour.
2. To reduce fatigue and boredom of work by avoiding unnecessary movements.
3. To find the best way of doing a job.
4. To have more effective utilization of material, machines and workers.
5. To improve the design of work place layout.
6. To standardise the method, obtained after conducting the motion study.
7. To train the individual worker in its practise as per standardized method.

See Appendix A for the Motion study procedures.

3.13 Case Of Study:

The carnality area up:-

Carnality solids harvested in the evaporation pans consist of a mixture of pure carnalities ($Kcl.Mgcl_2$ $.6H_2o$) & 16% NaCL as weight. The carnality slurry is received in four carnalities surge tanks, de-watered by carnality centrifuges and decomposed in agitated tanks with process water. The resulting solids from decompositions are KCL & NaCL. The mixture being commonly called sylvinite. Then sylvinite feed is de-watered by belt filters and washed. The resulting cake is conveyed to the sylvinite processing area. Only one operator assigned to the carnalities up area.

3.14 Operators Responsibilities:

1. follows up the continuity of the production line and maintains the best production specification in quality and quantity by direct interfering along with the concerned parties to fix any deviation from the process and operation limits (to reduce and minimize the cost.
2. Respect & follow all instructions
3. Respect attendance schedule
4. Housekeeping of overall appearance.
5. keeps the shift supervisor informed of the shift activities by preparing the daily shift operator report and serving recommendation to facilitate the work.
6. To maintain team work by cooperating between the unit
7. keeps the shift supervisor informed of the shift activities by preparing the daily shift operator report and serving recommendation to facilitate the work.

3.15 Carnality Area Tools, Materials & Equipments:

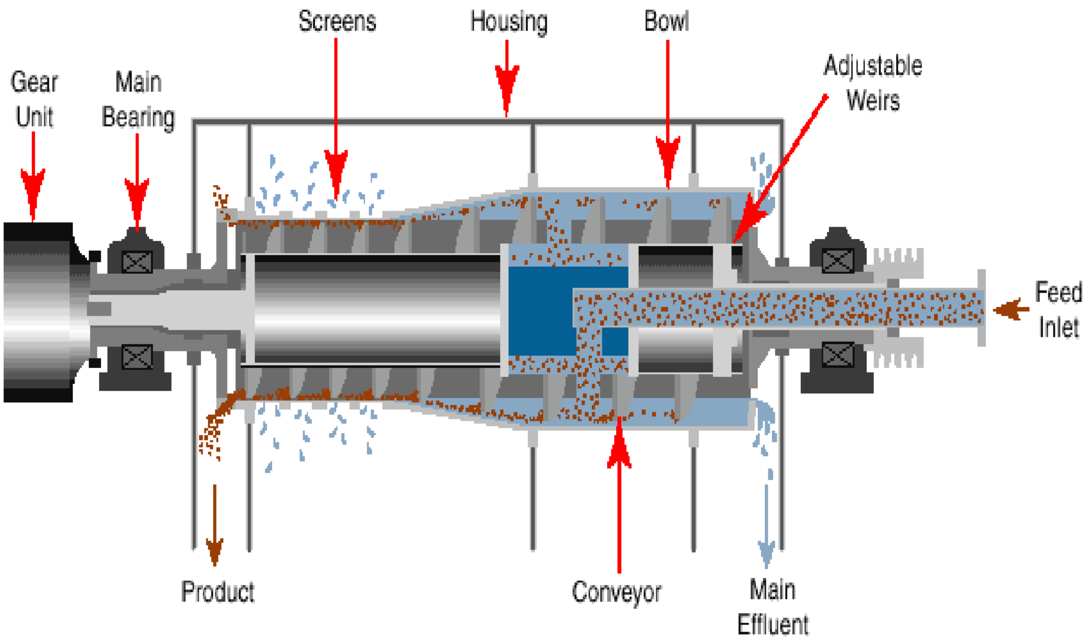
(1. Four Carnality surge tanks & 4Carnallite surge tank agitators
(2. Two Splitter box
(3. Primary received tank
(4. 12 Centrifuges
(5. Belt conveyors BC (11, 12, 20, 30)

3.16 Centrifuge:

Centrifuge, any device that applies a sustained centrifugal force; that is, a force due to rotation. Effectively, the centrifuge substitutes a similar, stronger, force for that of gravity. Every centrifuge contains a spinning vessel; there are many configurations, depending on use. A perforated rotating drum in a laundry that throws off excess water from clothes, for example, is a type of centrifuge. A similar type is used in industry to separate fluids from solid matter after crushing see fig.(3.11. As enunciated by Sir Isaac Newton in his first law of motion, a freely moving body (such as a ball) tends to travel in a straight line, and if directed along a curved path by some restraining force (such as would result were a hand-held string tied to it) it will exert a force against the directing or restraining force in its continual effort to fly off onto a

straight tangential course. The centrifugal force is directly proportional to the radius and to the mass, it is proportional to the square of the angular velocity. Centrifugal force is expressed by the basic relation [23].

Fig(3.11) The Main centrifuge components



$$F = mv^2 / R = 4\pi^2 mn^2 R; \qquad [23]$$

F: is the centrifugal force, m: the mass, R: the radius, V: the speed, n: the number of revolutions per second.

The rotating element of a centrifuge is usually driven about a fixed axis by an electric motor, or by an air turbine in some high-speed machines, and is known as a rotor, bowl, or drum. For the minimizing of vibration and strain on the shaft and bearings, it is essential that a loaded rotor be well balanced; *i.e.*, that its total mass be so distributed about the axis of rotation that the resultant of all the elemental forces is zero. The widest use of centrifuges is for the concentration and purification of materials in suspension or dissolved in fluids. Suspended particles denser than the suspending liquid tend to migrate toward the periphery, while those less dense move toward the centre. The rapidity with which the migration proceeds is dependent on the:

1. Intensity of the centrifugal field
2. The difference between the density of the particle and that of the suspending liquid
3. The viscosity of the liquid, the size and shape of the particle

4. And to some extent the concentration of the particles and the degree to which they are electrically charged. Centrifuges may be classified in three general categories depending on whether the spinning centrifuge bowl that contains the material to be separated has a solid wall, a perforated wall, or some combination of the two. Also, they may be characterized according to whether the material is treated in a continuous flow process, a batch process, or a combination of the above processes.

a. Safety Instruction:

1. High speed (100 rpm. It requires balance
2. Avoid all unsafe operation modes.
3. Good and clear communications is a must
4. Avoid an unauthorized changes or modifications.
5. All access (platform, ladder) to be kept clean.
6. Training on operation is a must.
7. Operator must forward directly any negative effects on centrifuges.
8. PPE must be used.

b. Centrifuge Operation:

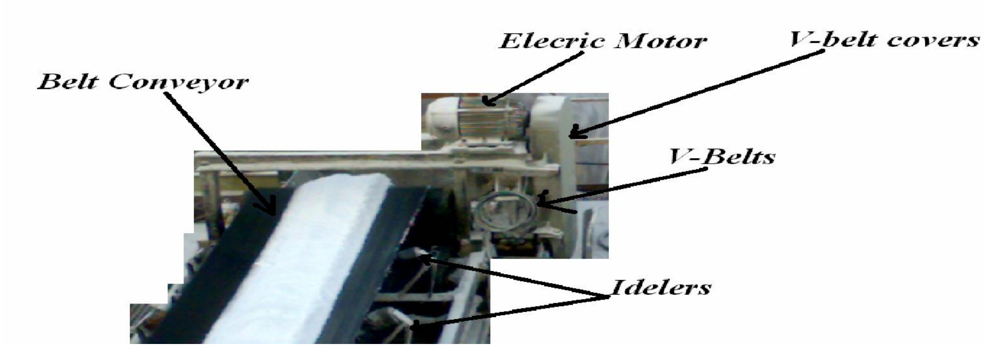
1. Insure completion of erection job before operation.
2. Immediately close feed valve in case of machine trip.
3. Mechanical: ensure that no parts left out during assembly.
4. Open the feed valve gradually during start up.
5. Excessive amount of feed during start up leads to clogging of screw.

c. Stopping The Centrifuge:

1. Close Supply Valve.
2. Open the flushing valves.
3. Shut off the main motor.
4. Stop flushing valves after shortly before motor standstill.
5. Restart the main motor for 30 sec to remove solids released during washing.

3.17 Belt Conveyors:

Fig. (3.12) The belt conveyor.



a. General description:

A belt conveyor consists of an endless belt with a relatively large width for conveyance mainly of solids. This belt has often a rubber cover with Coates a carcass. The belt is driven at one end by an electric motor and use of an intermediate speed reducer. The belt is supported by idlers and return rolls. The carrying idlers are toughed rollers; they allow material to be handled with a large capacity see fig (7.2. The return idlers are flat rollers.

b. Belt Deviation Control:

The straight line running of the belt conveyor is important in order to ensure design life of the belt:-

The belt deviation comes often from:

1- Dust on the carrying rollers and end pulleys.
2- Product feeding disinterred.

3.18 Operational Procedure For The Carnalities Up Area:

1. Seven harvesters gather the carnality solids from the pans & pumped to the plant using variable speed pumps. Harvester's feed is received in four carnality surge tanks.
2. Each of the two carnality surge tanks is pumped to the centrifuge feed box (splitter box) each feed splitter box feeding two trams of carnality centrifuges during normal operation.
3. There is 12 centrifuges 9 centrifuges are in line & three stand by or with maintenance.
4. The carnality solids are dewatered to decrease the amount of dissolved $MgCl_2$ and $CaCl_2$ entering the decomposition tanks, This will result in lower water consumption in decomposition.
5. Dewatered solids from carnality centrifuges are transferred by means of belt conveyors to the first tank in a series eight of decomposition tanks.
6. Carnality centrifuges filtrate flows by gravity to the carnality thickeners from which the underflow slurry is pumped to reactor where it is mixing brine from 1st stage decomposition thickener overflow.
7. From reactor slurry falls by gravity to wash thickener.
8. From wash thickener under flow slurry is pumped to decomposition tanks.

3.19 Motion Economy:

There are 26 principles of motion economy. Although they all are not applied to every operation but from basis or a code for improving the efficiency and reducing fatigue in manual work.

i. Principles related to the use of the " Human body " These are:

1. Both hands should start as well as complete their motion at the same time.
2. Both hands should not be idle at the same time except during rest periods.
3. Use both hands simultaneously and use best motion sequence.
4. Hand motions should be confined to the lowest possible classification in order to reduce fatigue. These are listed in order of giving least fatigue and maximum economy.
   First – Finger motions.
   Second- Finger and wrist motions.
   Third- Finger, wrist and lower arm motions.
   Fourth – Finger, wrist, lower arm and upper arm motions.
   Fifth-Finger, wrist, lower arm, upper arm and body motions.
5. Utilise momentum to assist the work, wherever possible.
6. Smooth continuous motions produce less fatigue in comparison to zigzag or straight line motions involving sudden and sharp change in direction.
7. Ballistic movements are faster, easier and more accurate than controlled movements.
8. Sequence of motions should be arranged to build rhythm and automat city into the operation.
9. Hands should be relieved of all work that can be done by feet or other parts of body.

ii. Principles related to the " arrangement of the work place".

1. All tools and materials should be placed at a definite and fixed place with easy reach.
2. All tools, materials and actuating devices should be placed in front of the operator at a distance as near as possible.
3. Provide gravity feed bins and use power or gravity conveyors to transport materials.
4. Wherever possible use drop deliveries. Drop delivery means dropping the article into a chute or on a conveyor as near to the point of assembly as possible so that gravity assists rather than the hands to reach the part to its required place.
5. Tools and material should be located in such a way as to achieve the best sequence of motions.

6. Illuminate the work places properly for adequate seeing and visual perception.
7. Provide proper working tables, stools and chairs, because to work in standing or sitting position on floor consumes more time and energy.
8. The height of the work place and chair, should be such that worker can either sit or stand comfortably.
9. Chairs provided should make good posture possible.
10. Keep the shops in good order, neat and clean.

iii. Principles related to the " Design of Tools and Equipment".

1. The hands should not be used for work that can be done more advantageously with the help devices.

   Therefore, following devices should be used to reduce manual work and to free both the hands as for as possible:

   a. Use power operated tools and equipments;
   b. Use vices, jigs and fixtures;
   c. Use stops, guides;
   d. Use foot pedals.
2. Reduced noise increases the speed of work and requires less energy.
3. Wherever practicable, tools and materials should be pre-positioned search, find and the select operations.
4. Wherever possible two or more tools should be combined.
5. Handles on tools and cranks should be designed to permit maximum contact with the hands, particularly where force is applied, such as in a screw driver, pliers, scrapper.
6. When each finger performs some specific movement, such as in type writing, the load should be distributed in accordance with the inherent capacities of the fingers.
7. The location of levers, cross bars and hand wheels, should be so decided that the operator can operate with the least change in body position and with greatest mechanical advantage.

3.20 Design Of Work Place Layout:

Bad working conditions always affect the productivity adversely. It has been established that comfortable work place will keep workers more satisfied and the more will be the productivity. Hence while designing a work place, its environment and such other factors must also be considered. The science which considers these entire factors is known as "Ergonomics". Ergonomics combines the knowledge obtained from the study of anatomy, physiology, psychology etc. to reduce the stress (like fatigue, eye strain, mental and muscular fatigue) on the workers in his work area.

While designing the machines and equipment, efforts are made to reduce these stresses and thus study on human and machine becomes

necessary. Thus the job of machine design is conducted by an ergonomics team which consists of engineers, designers, anatomists, physiologists and psychologists. Following are some of the important elements which are related to the workplace:

1. Cleanliness: as cleanliness affects on the worker's efficiency hence the working place must be clean. Work area must be clean and well painted.
2. Proper illumination: work place must be properly illuminated so as to avoid eye strain. Care must be taken to avoid glaring, flickering. Colour of light selected must be such as to reduce eye fatigue.
3. Noise: a work place must be selected so as to have as less noises as possible. Experiments have shown that reduction in noises results in increase in efficiency with lesser fatigue.
4. Location for Tools and Materials: all tools and materials required by workers must be located within the normal grasp area and as for as possible in front of the worker. These tools and materials when placed as near to the worker as possible, he will have to travel lesser distances to take these tools and materials again and again and then put them at their desired places which will be the loss of energy and time.
5. Proper Chairs: chairs permitting proper posture for the workers may be provided. This is possible when the worker is working or the work bench. Performing a job on floor in sitting position or on table in standing position requires more energy and time.
6. Work bench: all the tools and materials must be located with in the normal grasp area and as close in front of the operator as possible. Experiments have shown that a semi-circular table having a radius of 20" or 50.8cm from a point at 4" or 10.16cm back from the edge or work bench (4"or 10cm back gives approximately centre line of the operator shoulders and elbow) allows a most comfortable position. The work bench must be so designed so that use of both hands can be taken simultaneously.

The following table showing the time required for the main movement and the distance Table (3.10):

S. No.	Description	Distance in (m)	Time in (min)
1	Check the belt conveyor 20	26m	00:43:42
2	Checking the Belt conveyor 11&12	55m	02:36:06
3	Checking the Centrifuges floor	47m	04:36:06
4	Checking the splitter boxes	49m	00:35:94
5	Checking the Carnalities surge tanks agitators drive unit	84m	00:52:60
6	Taking % solid samples	84m	20:52:60
7	To reach the top floor from the ground floor	55	00:45:97
8	From the ground floor to reach the W.C toilet	105m	00:52:51

For the carnality up area the following modification should be done:

1. Installing electrical elevator to avoid the vertical movement from one floor to another.
   Using elevators to transport from one floor to another we need at least (00:16: 5) min but without elevators we need (00:33:15)min so we can save (00:16:65)min for each vertical movement.
2. To reduce the time to reach the toilet from the ground floor we need to install a toilet near the centrifuges floor therefore we can reduce about (00:52:51) min and (105m) distance.
3. There is several sharp edges should be rounded and several crowded area with small entrance should be modified to avoid the unnecessary movement and sudden accidents.
4. The lighting units in this unit with yellow colour it should be replaced with white colour for proper illumination .
5. If we install 3cameras in the following places we can reduce a lot of general movement and we can facilitate the carnality up area monitoring:
   a. The carnalities surge tanks top floor so we can see the levels of the tanks actually, the agitators movement and any problems that can occurs in the top floor.
   b. The belting system to monitor the belts movement and any deviation or sudden trip reasons for belts conveyor 11, 12, 20.

c. For the centrifuges floor to check any trouble or sudden stopping of any centrifuge.

6. For the carnality up % solid we can use density meters to check the % solid of the carnalities surge tank overflow so we can control the harvesters flow directly from the control room.
7. For the operators cabinet we need to change the table and chair of the exits unit to get more relaxation .

As noted before that:

Proper Chairs: chairs permitting proper posture for the workers may be provided. This is possible when the worker is working or the work bench. Performing a job on floor in sitting position or on table in standing position requires more energy and time.

Work bench: As explained earlier, all the tools and materials must be located within the normal grasp area and as close in front of the operator as possible. Experiments have shown that a semi-circular table having a radius of 20" or 50.8cm from a point at 4" or 10.16cm back from the edge or work bench (4" or 10cm back gives approximately centre line of the operator shoulders and elbow) allows a most comfortable position.

The total distance moved can be calculated:

From the ground floor to reach the W.C toilet	= 105m.
To reach the top floor from the ground floor	= 55m.
Checking the Carnalities surge tanks agitators drive unit, levels & to take % solid	= 84m.
Checking splitter boxes	= 49m.
Checking Centrifuges floor	= 141m.
Checking Belt conveyor 11&12	= 165m.
Checking belt conveyor 20	= 52m.
The total distance	= 651m.

The saved distance can be calculated as follows:

From the ground floor to reach the W.C toilet = 105m

By installing toilet near the operator room.

To reach the top floor from the ground floor = 55m.

By using electrical elevator.

The total distance saved = 160m.

The % of saved distance = $\frac{160}{650} \times 100\ \% = 24.58\ \%$.

Total time required to check the carnalities up area:

Check the belt conveyor 20	= 00:43:42 min
Checking the Belt conveyor 11&12	= 02:36:06 min
Checking the Centrifuges floor	= 04:36:06 min
Checking the splitter boxes	= 00:35:94 min
Checking the Carnalities surge tanks	= 00:52:60 min

Taking % solid samples = 20:52:60 min
To reach the top floor from the ground floor = 00:45:97min
From the ground floor to reach the W.C toilet = 00:52:51 min

Total time to check car . Area = 29:55:16min

The total time that we can save for each movements:

From the ground floor to reach the W.C toilet = 00:52:51min
By installing toilet in the centrifuge floor
For each vertical movement we have 4 floor 4 x 00:16:65=
By installing electrical elevator = 01:07:00min
Check the belt conveyor 20 = 00:43:42 min
By installing camera
Checking the Belt conveyor 11&12 = 02:36:06 min
By installing camera Then
Time saved = 05:19:39min

The Save time % = $\dfrac{5:19:39 \times 100\ \%}{29:55:16}$

$= \dfrac{5.19 \times 100\ \%}{30} = 17.3\%$

3.21 Machine Interference:

In multi-machine operation a number of machines can be attended by one operator, then some problems arise, such as calculation of machine of machine capacities, production output, number of machines units to be attended by one or group of operators. If too few machines assigned, labour cost will be more if too many are assigned, the machines will be idle and the cost for this excess machine capacity will become burdensome. Following are the factors which are needed to be defined before proceeding further:

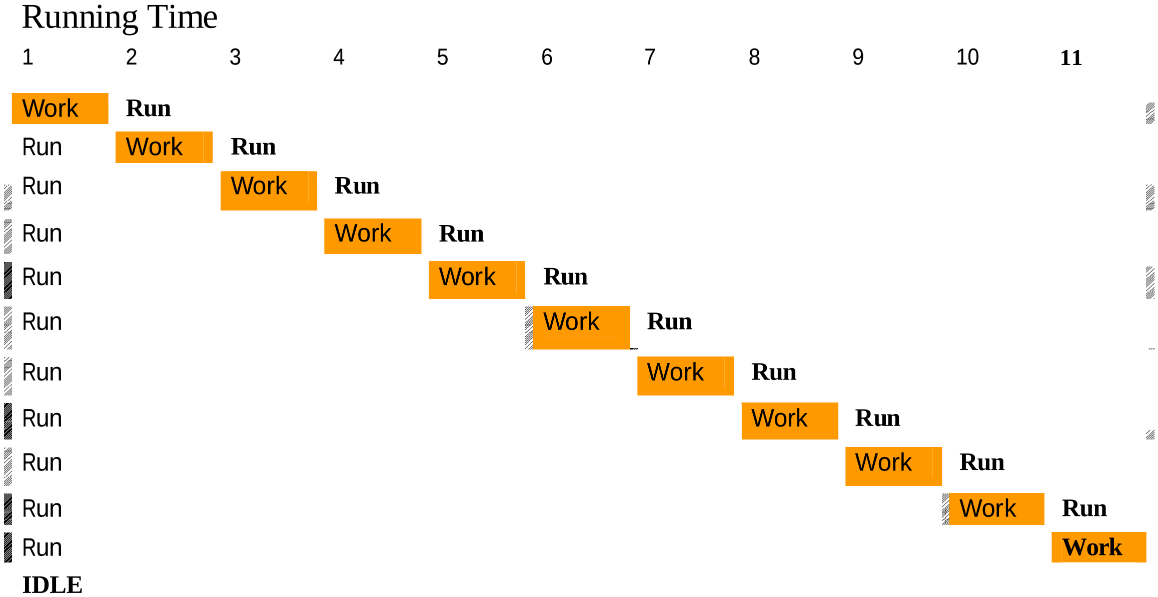
a. Multi Machine Operation:
It is the simultaneous operation of more than one machine units by one group of operators. In equation, N represents the number of identical machine units to be used.

b. Running Time: It is the time necessary for a machine unit to run without any break to produce one unit of output. This is represented by word R.

c. Working Time: It is the time an operator must work on the machine units to produce a single unit of output. It is represented by the word W.

d. Interference: It is the time for which one or more machine units are idle while the attendant is occupied which the work on other machine units. Interference is represented by the word I.

Fig. (3.13) Operation of 12 Machine units.



To understand how the above mentioned factors used in determining the outputs, let us assume that in the carnality up area line the running time per unit (R) is 11 minutes. Assume also that working time (W) per unit of output is one minute. Suppose 12 machines are assigned to one operator. The operation cycle is shown in Fig.(3.13)from which it is quite clear that one machine unit will be idle while the operator takes care of the others.

Without considering the factors of interference a good approximation of the proper number of machine units to be assigned to an operator, can be calculated by:-

N =(R+W) / W. [1]

For the carnality area N= 11+1/1= 12.

The effect of interference occurs when an operator usually attends to several semi-automatic machine units. For a given output, there may be times when all machines are working and the operator is merely waiting for something to happen as in case of allotting 12 machines to an operator. There may be possible when many of machines are shutdown simultaneously though in most cases operator cannot do anything but there is interference idleness.

As per engineer's point of view, the machine interferences is important in two respects. First is to know that how many machines should be assigned to an operator, in which machine interference should be known. The second one, to find out the operators actual productive efficiency for wage incentive purpose, for which loss of production caused by machine interference has to be evaluated. Much time was spend by time study men in evaluating machine interference by use of

stop watches. But they are not successful due to unpredictable, variable shutdowns of machine units. Since machine interference in unpredictable and variable in magnitude, a mechanical technique is evolved which takes into account such uncertainty. This technique is based on the law of probability, which states " that when an event is based on chance as pertaining to each of several participants acting together, the various possible combinations of occurrence of that event will be disturbed according to the terms of binomial expansion,

$(d + r)^n = d^n + n\, d^{n-1} r + [\, n(n-1) d^{n-2} r^2 \,] / 1(2) + \ldots + r^n$ [1]

Where

d = probability of occurrence
r = probability of non – occurrence
n =Number of machines.

Or

$$b(x; n, d) = \binom{n}{x} d^x r^{n-x} \qquad [18]$$

Using interference for carnality centrifuges area:

Supposing , at the end of the day , the down time (non-producing time) Per machine was 20 percent of the time for which 12 percentage interference per machine for the period of operation:

d= 20%, i.e. (1/5), r = (4/5), n =12.

$[(1/5) + (4/5)]^{12} = (1/5)^{12} + 12(1/5)^{11}(4/5) + \ldots.. + r^n$

Putting in form of Table (3.11):

No. of Mach. DT (1)	Coefficients Sum (2)	(d) (3)	(r) (4)	Wait (5)	Interference = (2)*(3)*(4)*(5) (6)
12	1	$(1/5)^{12}$	$(4/5)^0$	11	(11/ 244140625)
11	12	$(1/5)^{11}$	$(4/5)^1$	10	(480/ 244140625)
10	66	$(1/5)^{10}$	$(4/5)^2$	9	(9505/ 244140625)
9	220	$(1/5)^9$	$(4/5)^3$	8	(112640/ 244140625)
8	495	$(1/5)^8$	$(4/5)^4$	7	(887040/ 244140625)
7	792	$(1/5)^7$	$(4/5)^5$	6	(4866048/244140625)
6	924	$(1/5)^6$	$(4/5)^6$	5	(18923520/ 244140625)
5	792	$(1/5)^5$	$(4/5)^7$	4	(51904512/ 244140625)
4	495	$(1/5)^4$	$(4/5)^8$	3	(97320960/ 244140625)
3	220	$(1/5)^3$	$(4/5)^9$	2	(115343360/244140625)
2	66	$(1/5)^2$	$(4/5)^{10}$	1	(69206,016/ 244140625)
1	12	$(1/5)^1$	$(4/5)^{11}$	0	0
0	1	$(1/5)^0$	$(4/5)^{12}$	0	0

$\sum$ Interference = (358574091 / 244140625)

= 1.4687

Since there are 12 machines in the group the average interference per machine = 1.4687 / 12.

= 0.12239

= 12.239 %.

Further as shown (d) is equal to average servicing time plus average interference time so the average servicing time = 20 – 12.24

= 7.761%.

3.22 Classification Of Forecasting Methods:

A useful classification of forecasting methods concerns the time in the future which is considered. In particular:

Short term forecasts cover the next few months (the continuing demand for a product, for example)

Medium term forecasts look ahead between a few months and two or three years (say, the time needed to replace an old product by a new one)

Long term forecasts might look ahead several years (the time needed to build a new factory.

The time horizon affects the choice of forecasting method, because of the availability and relevance of historic data, the time available to do the forecasting, the cost involved and the effort considered worthwhile. In essence, long – term forecasts are concerned with strategic decisions, medium –term forecasts with tactical decisions, and short – term forecasts with operational decisions. Inventory control is primarily concerned with short term forecasting .This means there usually enough relevant data to allow good forecasts. Sometimes, however data is not available when, for example, a new item is added to the inventory forecasting demand for a new item, for which there is no historic data, must used qualitative approach. Such methods are generally referred to as judgemental, and they rely on subjective assessments and opinions. Items which have been in stock for some time will have records of past demand and the factors which affect this. Then more reliable quantitative forecasts can be used.

There are two distinct approaches to quantitative forecasting:

Casual methods which analyse the effects of outside influences and use these to produce forecasts. Sale of an item might, for example, depend directly on the price charged, so that future sales can be forecast from the planned future price.

Projective methods which examine the pattern of past demand and extends this into the future. If demand in the past four months has been 20, 25, 30 and 35, it would be reasonable to project this pattern and suggest that demand in the next month will be around 40.

Thus we have three distinct approaches to forecasting: -

1. Judgemental methods, which rely on subjective assessment.
2. Casual methods, which look at external factors and use these to forecast demand.
3. Projective methods, which project past demand for an item into the future.

3.23 Judgemental Forecasts For New Stock Items:

Judgemental forecasting methods are subjective assessments, usually based on the opinions of experts. They are not usually as reliable as quantitative forecasts, but they are very flexible and can be used in a wide range of circumstances. If for example an organisation is about to stock an entirely new items there is no appropriate historic data and it must, use a judgemental forecast. Sometimes, even when there is data, it is unreliable, out of date, or irrelevant to the future. In these cases quantitative forecasts cannot be used and judgemental methods are the only alternative.

Judgemental forecasts collect opinions from various experts in the field. For inventory systems these experts might include suppliers, purchasing departments, store keepers, salesmen, customers, organisations supplying similar or related items, trade reviews, government publication, and so on.

Here we will outline five widely used methods of judgemental forecasting:

1. Personal insight
2. Panel consensus
3. Delphi method
4. Historic analogy
5. Market surveys

1. Personal Insight:

This uses a single expert who is familiar with the situation to produce a forecast based on his or her own judgement. This is the most widely used forecasting method, and is the one which managers should try to avoid. It relies entirely on one person's judgement (opinions, prejudices and ignorance. Personal insight can give good forecasts, but often gives very bad ones and there are countless examples of experts being totally wrong. Perhaps the major weakness of the method is its unreliability. This may not matter for minor decisions, but when the consequences of errors are large some more reliable method should be used. Comparisons of forecasting methods clearly show that someone who is familiar with a situation and uses experience and subjective opinions to forecast will consistently produce worse forecasts than

someone who knows nothing about the situation but uses a more formal method.

2. Panel Consensus:

As unreliability is the main problem with personal insight, collecting together several experts and allowing them to talk freely to each other, should lead to consensus which is more reliable. When there is no secrecy and the panel are encouraged to talk openly, a genuine consensus can be found. Conversely, there may be difficulties getting the panel to talk openly, and in combining the views of different experts when a consensus is not found. Although it is more reliable than personal insight, panel consensus still has the major weakness that all experts can make mistakes. There are also problems of group working, where " he who shouts loudest gets his way", everyone tries to please the boss, some people do not speak well in groups, and so on. Overall, panel consensus is an improvement on personal insight, but results from either method should be viewed with caution.

3. Delphi Method:

This method is an improvement on panel consensus as it overcomes the problems with face – to – face discussions. A number of experts are contacted by post and each is given a questionnaire to complete. The replies from these questionnaires are analysed and summaries are passed back to the experts. Each expert is then asked to reconsider his or her original reply in the light of the summarised replies from others. Each reply is anonymous so that undue influences of status and the pressures of face –to- face discussions are avoided. This process of modifying responses in the light of replies made by the rest of the group is repeated several times (often between three and six. By this time, the range of opinions should have narrowed enough to help with decisions.

4. Historic Analogy:

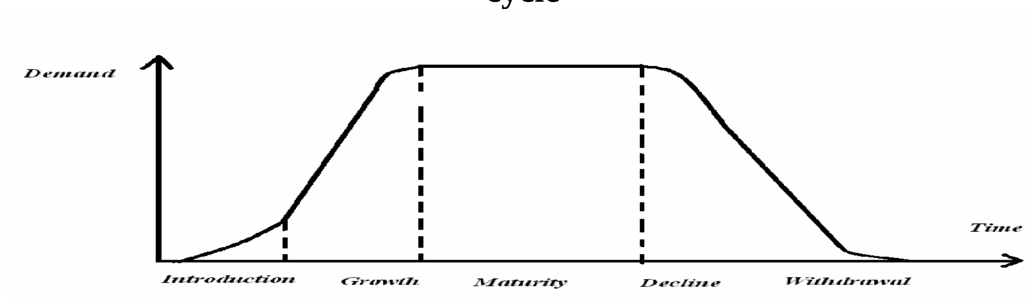
The demand for most products follows a common pattern through their lifetime.

In particular, sales go through period of:

4.1. Introduction
4.2. Growth
4.3. Maturation
4.4. Decline
4.5. Withdrawal

As illustrated in fig.(3.14) Historic analogy uses the demand of a similar item which was introduced in the past to judge the demand for a new item. When a new item is to be introduced an organisation can look for a comparable item which was lunched recently and assume that demand for the new item will follow a similar pattern. If, for example a television retailer is ordering a new type of set, it could forecast demand by reviewing demand for the last set it stocked. The main problems with historic analogy are finding a recently introduced product with enough similarities, and fitting the characteristic life cycle curve to actual demand.

Figure (3.14) Demand at different stages in a typical product life cycle



5. Market Surveys:

Sometimes, particularly with the launch of a new product, the opinions of experts are not reliable enough to make a satisfactory forecast. Then more useful information can be found by talking directly to potential customers. Market surveys collect data from a representative sample of customers. Their views are analysed, with inferences drawn about the population at large.

Market surveys can give useful information but they tend to be expensive and time consuming. They are also prone to errors as they rely on :

1. A sample of customers which is representative.
2. Useful, unbiased questions.
3. Reliable analysis of the replies.
4. Valid conclusions drawn from the analyses.

Each of the judgemental methods is appropriate in different circumstances. If a quick reply is needed, personal insight is the fastest and cheapest method. For many inventories, suppliers provide the best source of information. They have contact with similar organisations and can give useful advice. This does, however, need a supplier who is objective and is not trying to make short – term gains. If more reliable forecasts are needed it may be worth organising a market survey or

Delphi method. We should always bear in mind that inventory systems are insensitive to small errors.

3.24 Projective Forecasting:

Projective forecasting is intrinsic, in that it uses only historic values for demand to forecast future demand. Any external influences are ignored.

Types of projective forecasting:-

1. Simple averages.
2. Moving averages.
3. Exponential smoothing.
4. Models for seasonality and trend.

1. Simple Averages:

An obvious method of projective forecasting is to look at records for previous demand and take the average of these.

Simple averages forecasting:

$F(t+1) = 1/N * \sum_{t=1}^{N} D(t)$ [33,34]

Where:

N = Number of periods of historic data
t = Time period
D(t) = demand at time t
F(t + 1) = forecast for time t + 1

For the following demand we want to forecast the demand for period six of the following time series of potash daily demand using simple average. Worked example (1):

Table(3.12) daily potash demand of 2 series for worked example (1.

Period	t	1	2	3	4	5	6
Series 1	D(t)	5084	4654	3855	4188	2556	
Series 2	D(t)	4654	3855	4188	2556	5084	

Solution:

Series 1 $F(6) = 1/5 * \sum_{t=1}^{N} D(t)$

$= 1/5 * 20337$

$= 4067.4$

Series 2 $F(6) = 1/5 * \sum_{t=1}^{N} D(t)$

$= 1/5 * 20337$

$= 4067.4$

Simple averages assume the demand to be constant. There fore, the forecasts for period 50 are the same as the forecasts for period 6 (i.e. 4067.4)

Using simple averages to forecast demand is easy and can give good results when demand is constant (or at least relatively stable) unfortunately, it does not work will if the demand pattern is changes. Then older data tends to swamp the latest figures and the forecast is very unresponsive to the change.

In general forecasting with simple averages can give good results if demand is constant. For any other pattern some alternative method should be used. One way around is to ignore old data.

2. Moving averages:

The problem with simple averages is that old data, which may be out of date, tends to swamp newer, more relevant data. One way around this is to ignore old data and only use the most recent values in forecasts. This is the principle of moving averages. The demand for most items changes over time, so that only a certain amount of historic data is relevant to future forecasts. The implication is that all observations older than some specified value can be ignored. This suggests an approach where the average demands over, say, the past ten periods is used in forecasting, and any data older than this is ignored. This is the basis of moving averages.

Moving average forecasts are found from:

F (t+1) = average of N most recent pieces of data

= [latest demand + next latest + … + Nth latest] **/** N

= [D(t) + D(T-1) + .. + D (t- N + 1)] / N

Worked example (2) :- see table (3.13) demand for potash over the past six periods has been as follows:

Table (3.13) Potash daily demand for worked example (2)

T	1	2	3	4	5	6
D (t)	5084	4653	3855	4188	2556	3759

If data over three periods old is no longer considered relevant, use a moving average to forecast the demand for the item:-

Solution: - Only data more recent than three periods is relevant. So we can use a three period moving average for the forecast. If we consider the situation at the end of the 3, the forecast for period 4 is: -

N = 3

F (4) = [D (1) + D (2) + D (3)] / 3

= [5084 + 4653 +3855] / 3

= 4531

At the end of period 4, when the demand is known to be 4188, this forecast is updated to give:-

F (5) = [D (2) + D (3) + D (4)] / 3
= [4653 + 3855 + 4188] / 3
= 4232

F(6) =[D(3) + D(4) + D(5)]/ 3
= [3855 + 4188 + 2556]/ 3
= 3533

F(7) =[D(4) + D(5) + D(6)]/ 3
= [4188 + 2556 + 3759] / 3
= 3501

A large value of N takes the average of many observations and the forecast is unresponsive. The forecast will smooth our random variations, but will be slow to follow genuine changes in demand.

A small value of N gives a responsive forecast which quickly follows genuine changes in demand, but may be too sensitive to random fluctuations.

Worked example (3) with deferent value of N:

Demand for potash over the past 9 days as follows see table (3.14):

Using moving averages with N = 3 and N = 4 and N = 6 to produce one period ahead forecast: -

Table (3.14) Demand for potash over the past 9 days for worked example (3)

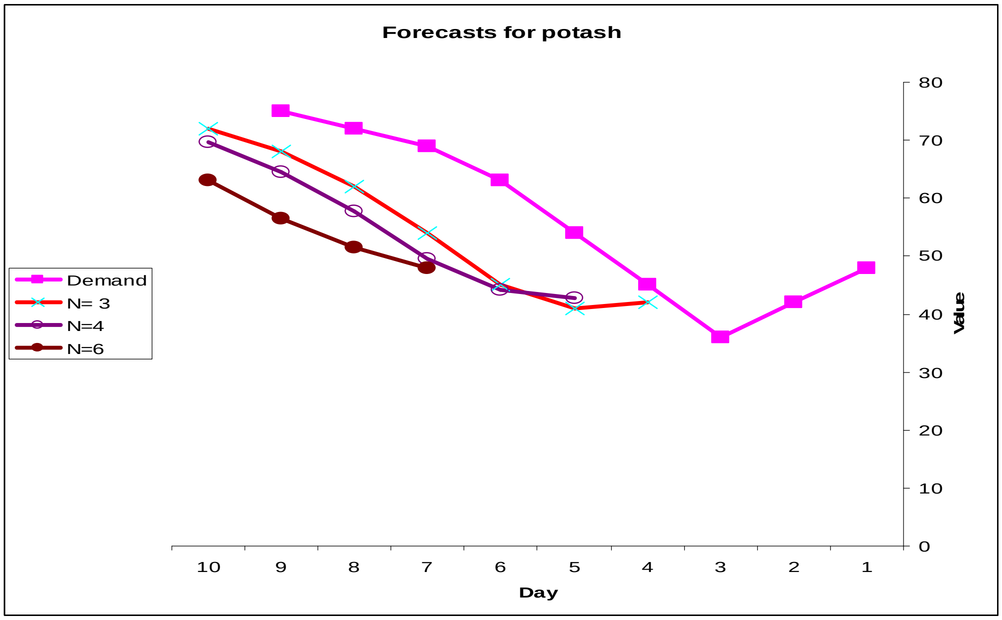
Day	1	2	3	4	5	6	7	8	***9***
De	4085	4132	4408	3136	3999	3149	3740	3056	4987

Solution:

Table (3.15) the final result for worked example (3)

Day	Demand	Forecasts		
		N= 3	N= 4	N= 6
1	4085	-----	-----	-----
2	4132	-----	-----	-----
3	4408	-----	-----	-----
4	3136	4208	-----	-----
5	3999	3892	3940	-----
6	3149	3848	3919	-----
7	3740	3428	3673	2349
8	3056	3629	3506	3761
9	4987	3315	3486	3581
10		3928	3733	3678

Fig.(3.15)forecast for worked example(3) applying moving average



This fig . (3.15) shows how the three – day moving average is most responsive to change and the six- day moving average is the least responsive. A particularly useful property of moving average is the way they smooth the out demands which have strong seasonal variations. If N is chosen to equal the number of periods in a season, a moving average will completely depersonalise data.

3. Exponential Smoothing:

Exponential smoothing is based on the idea that as data gets older it becomes less relevant and should be given less weight. The method, then, gives high weight to most recent data, but the weight declines exponentially with the age of data. As shown if fig.(7.6. This declining weight can be achieved using only the latest demand figure and the previous forecast. In particular, a new forecast is calculated by taking a proportion, α of the latest demand and adding a proportion,
1- α, of the previous forecast.
New forecast = α * latest demand + (1- α) * last forecast
F (t +1) = α * D(t) + (1- α) F(t. [33, 34]
→ Where α is the smoothing constant which is usually given a value between (0.1) and (0.2)
We can illustrate the way exponential smoothing adapts to changing demand by rearranging the formula:
F(t +1) = α * D(t) + (1- α) F(t.

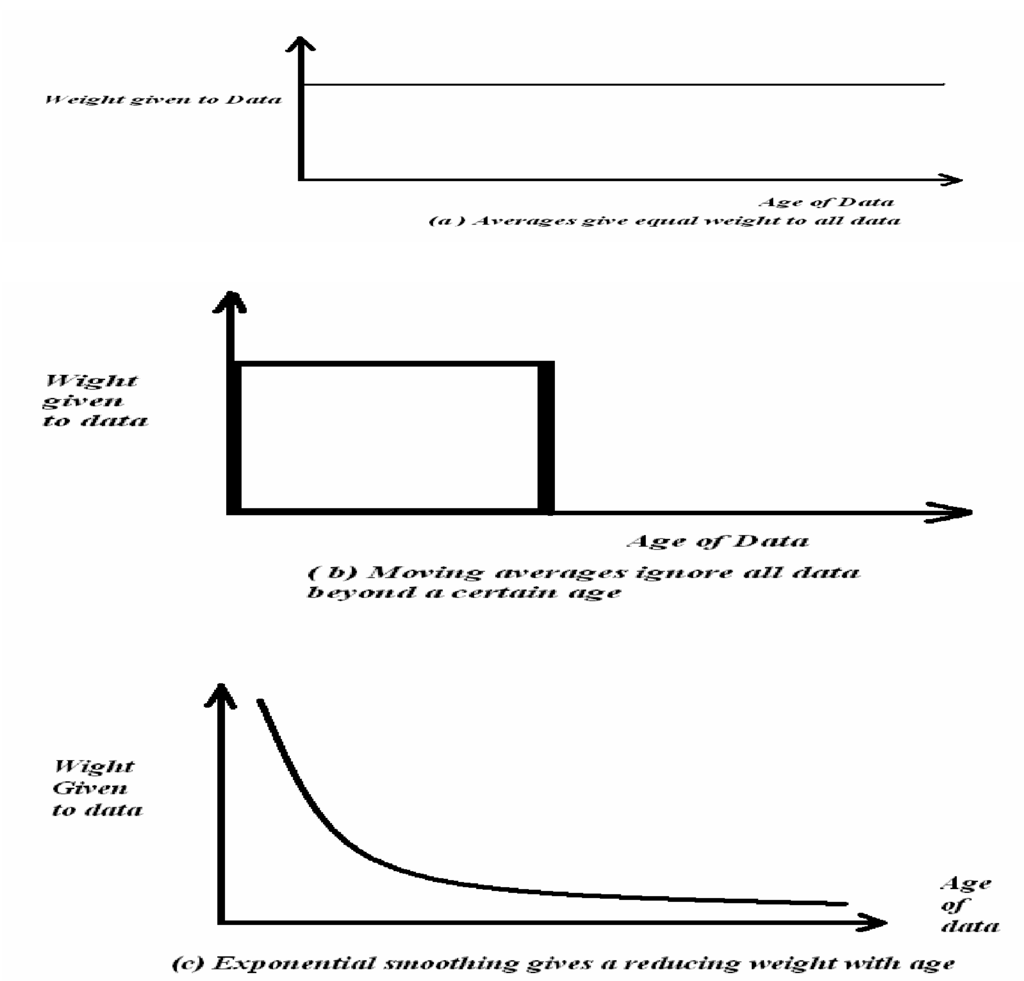
$$= F(t) + \alpha [\, D(t) - F(t) \,]$$

$$E(t) = D(t) - F(t)$$

$$F(t+1) = F(t) + \alpha * E(t)$$

Thus the error in each forecast is noted and a proportion is added to adjust the next forecast. This gives a continuously self – correcting method where larger errors in the last forecast lead to larger adjustments in the next forecast.

Fig.(3.16)Weight given to different forecasting methods(a) actual averages give equal weight to all data (b) Moving averages ignore all data beyond a certain age(c) Exponential smoothing gives a reducing weight with age .



Worked example (4)

Using exponential smoothing with α = 0.2 and an initial value of F(1) = 4301 to produce one period ahead forecast for the following potash demand

Table (3.16) Daily potash demand for worked example (4)

Day	1	2	3	4	5	6
Demand	4152	4585	5334	4865	6209	6159

Solution:

We know the F (1) = 4301

$\alpha = 0.2$

Substitution then gives:

F (2) = α * D (1) + (1- α) F(1.

= 0.2 * 4152 + 0.8 * 4301

F (2) = 4271

F(3) = α * D(2) + (1- α) F(2.

= 0.2 * 4584 + 0.8 * 4271

F(3) = 4334.

And so on, as shown in the following table:

Table (3.17) Result of worked example (4)

t	1	2	3	4	5	6	7
D(t)	4152	4585	5334	4865	6209	6159	——
F(t)	4301	4271	4334	4534	4600	4922	5169

Note the exponential smoothing actually does give less weight to data as it gets older.

We can demonstrate this by taking an arbitrary value.

Let :-

F(t+1) = α D(t) +(1 –α)F(t)

Using α = 0.2

F(t+ 1)= 0.2*D(t)+ 0.8* F(t.

By substituting (t -1) for t gives:

F(t) = 0.2 * D(t-1) + 0.8F(t-1)

And using this in the equation above gives: -

F(t+1)=0.2*D(t)+ o.8* [0.2 *D(t-1) +0.8*F(t-1)]

= 0.2* D(t)+ 0.16* D(t-1) + 0.64*F(t-1.

But

F(t-1) = 0.2* D(t-2) +0.8* F(t-2)

So

F(t+1) =0.2* D(t)+ 0.16* D(t-1)+ 0.64* [0.2* D(t-2) +0.8* F(t-2)].

=0.2* D(t) +0.16*D(t-1)+0.128*D(t-2)+0.512* F(t-2.

But

F(t-2)= α D(t-3)+(1- α) F(t-3)
So
F(t+1)= 0.2*D(t)+0.16*D(t-1) +0.128*D(t-2)+0.512 [0.2*D(t-3)+0.8* F(t-3)].
Then
F(t+1) = 0.2* D(t)+ 0.16*D(t-1)+0.128*D(t-2)+0.1024*D(t-3) +0.4096*F(t-3.
But
F(t-3) = 0.2* D(t-4)+ 0.8*F(t-4.
So
F(t+1) = 0.2*D(t) +0.16*D(t-1)+0.128*D(t-2)+0.1024*D(t-3)+0.08192* D(t-4) +0.32768* F(t-4.
But
F(t-4) = 0.2 * D(t-5)+0.8* F(t-5.
So
F(t+1) = 0.2*D(t) +0.16*D(t-1)+0.128*D(t-2)+0.1024*D(t-3)+0.08192* D(t-4) +0.065536* D(t-5) +0.262144*F(t-5.
The weight put on older data is getting progressively less, and the above calculation could be considered to give weights shown in Table (3.18.

Table (3.18)

Age of data	weight
0	0.2
1	0.16
2	0.128
3	0.1024
4	0.08192
5	0.065536
6	0.0524288
etc	etc

The value given to the smoothing constant, α, is important in setting the responsiveness of the forecasts.
A high value of α, perhaps around 0.3, puts more emphasis on the latest demands and gives a responsive forecast.
A low value of α, perhaps around 0.1, puts more emphasis on previous forecasts and gives a less responsive forecast.
Worked example (5):
For the following time series use an initial forecast of (3470) to compare exponential smoothing forecasts with varying values of α:

Table (3.19) Demand of daily potash for worked example (5)

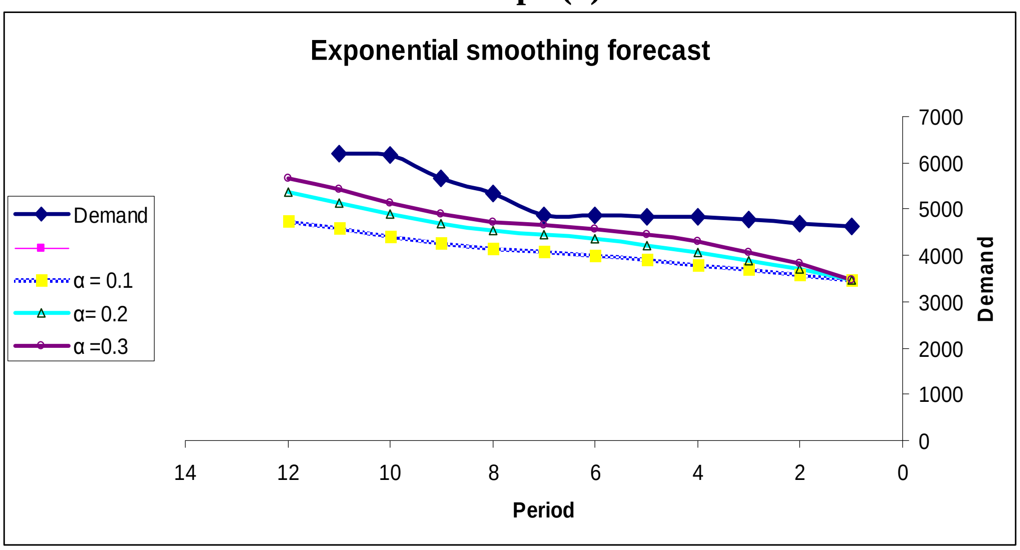
Time	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
D (t)	**4635**	**4681**	**4788**	**4821**	**4847**	**4851**	**4865**	**5334**	**5654**	**6159**	**6209**

Take the value of α =0.1, α = 0.2, α = 0.3

Table (3.20) Results for worked example (5)

Period	demand	forecast		
		α = 0.1	α = 0.2	α = 0.3
1	4635	3470	3470	3470
2	4681	3587	3703	3820
3	4788	3696	3899	4078
4	4821	3805	4077	4291
5	4847	3907	4226	4450
6	4851	4001	4350	4569
7	4865	4086	4450	4654
8	5334	4164	4533	4717
9	5654	4281	4693	4902
10	6159	4418	4885	5128
11	6209	4592	5140	5437
12	——	4754	5354	5669

Figure (3.17)The exponential smoothing forecast for worked example(5)



Taking value of α = 0.1, α =0.2, α =0.3 gives the results shown in table

(7.9) all these forecasts would eventually follow the sharp step and raise forecasts to around 5260.

Higher values of α make this adjustment more quickly and give a more responsive forecast, as shown in figure (3.17) although higher values of α give more responsive forecasts, they do not necessarily give more accurate ones.

Demand always contains random noise, and very sensitive forecasts tend to follow these random fluctuations.

4. Models for Seasonality and Trend

Exponential smoothing is currently the most widely used forecasting method for inventory control. In its standard form, however, it does not cope well with demand which is either seasonal or has a trend.

"Trend" is the amount by which demand grows between two consecutive periods. If two consecutive periods have demands of 50 and 60 the trend is 10: if two consecutive periods have demands of 110 and 100 the trend is 10.

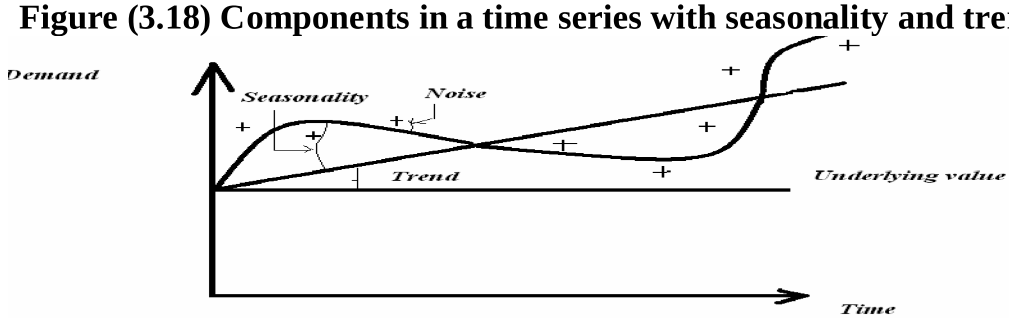
"Seasonality" is a regular cyclical pattern, which is not necessarily annual. It is measured by seasonal indices, which are defined as the amounts depersonalized values must be multiplied by to get seasonal values. Then: Seasonal index = seasonal value / depersonalized value

If a newspaper has average daily sales of 100 copies in a particular area, but this rises to 200 copies on Saturday and falls to 50 copies on Monday and Tuesday. The depersonalized value is 100, the seasonal index for Saturday is 2.0, the seasonal index for Monday and Tuesday are 0.5, and seasonal indices for other days are 1.0.

The demand is split into four components (see figure 3.18)

1. Underlying value (which is the basic value of demand)
2. Adjustment for trend (which is an addition or subtraction to allow for steady increases or decreases)
3. Seasonal index (which allows for regular cyclical variation)
4. Random noise (which cannot be forecast.

Figure (3.18) Components in a time series with seasonality and trend



D (t) = [underlying value + adjustment for trend]* seasonal index + noise

The steps in forecasting are then:

1. Depersonalise demand and use exponential smoothing to give the smoothed underlying value.
2. Use exponential smoothing on the trend to give a smoothed adjustment for trend.
3. Use exponential smoothing on the seasonal index to give the smoothed index for the period
4. Add the smoothed underlying value to the smoothed trend adjustment and multiply by the seasonal index to give the forecast

F (t+ 1) = [smoothed underlying value + smoothed adjustment for trend] * smoothed seasonal index

$F(t + 1) = [U(t) + T(t)] * I(n)$

Where U (t) = smoothed underlying value for period t

T (t) = smoothed trend for period t

I (n) = smoothed seasonal index for period t, which is the n'^{th} period of a cycle.

Worked example (6):

Over the past 12 periods demand for potash has been as follows:-

Table (3.21) Potash daily demand for worked example (6)

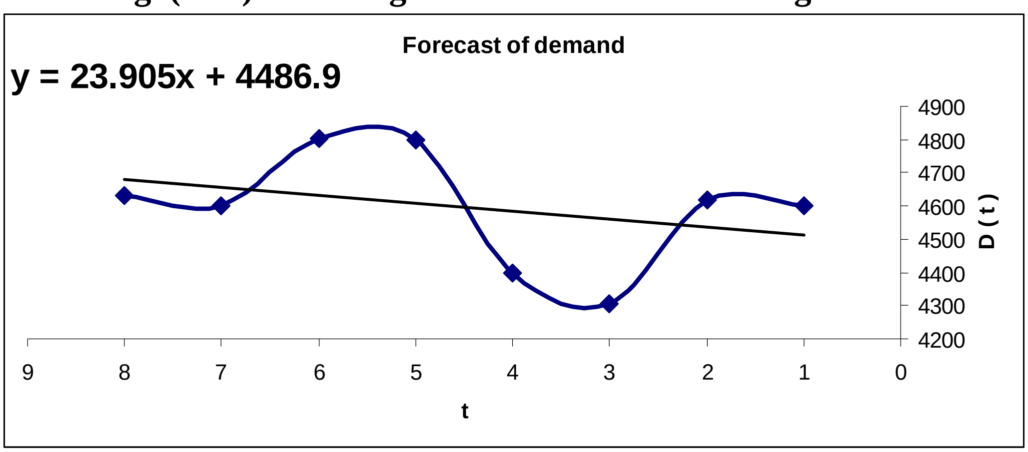
t	**1**	**2**	**3**	**4**	**5**	**6**	**7**	***8***
D(t)	**4602**	**4620**	**4304**	**4396**	**4798**	**4804**	**4604**	**4630**

t	**9**	**10**	**11**	***12***
D (t)	**4941**	**4896**	**4665**	**4736**

Forecast the demand for the next three periods

Solution see Appendix B for the calculation procedure:

Fig. (3.19) linear regression line for forecasting demand



a = 4486.9

b = 23.905

This regression line effectively gives depersonalised values .

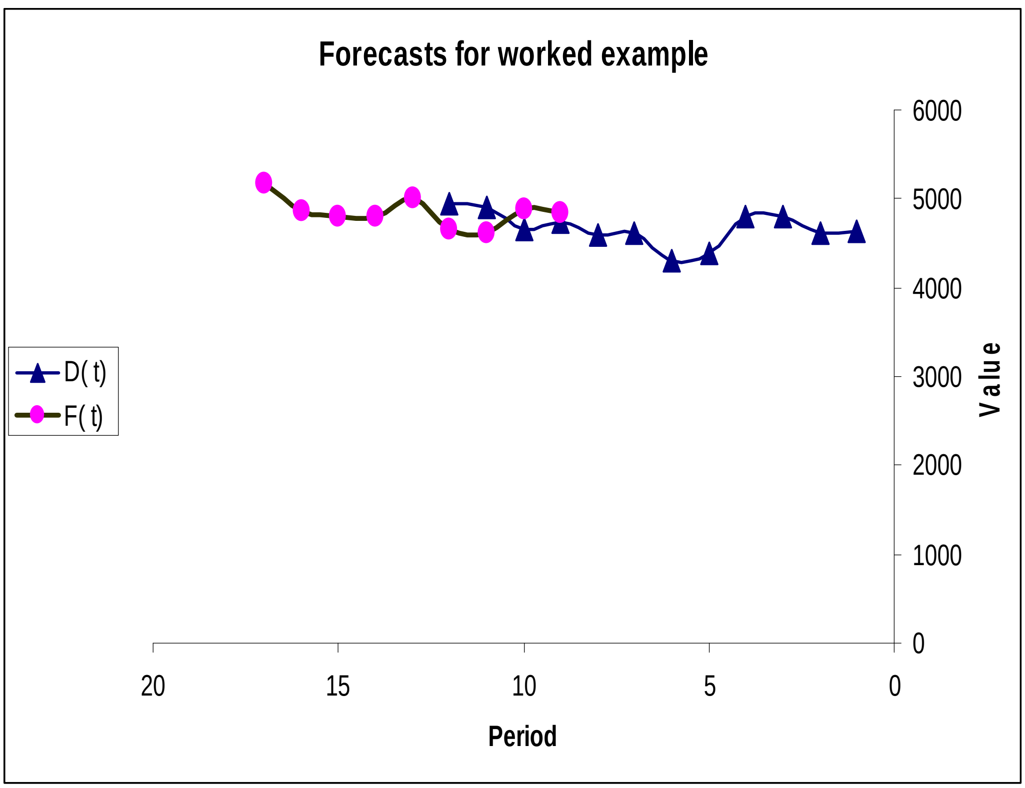
Then by taking the ratio of actual demand to depersonalised demand we can calculate seasonal indices as shown in the following table (3.22.

Table (3.22) Seasonal index final results

t	valueDe-seasonal	Seasonal value, D(t)	Seasonal index
1	4511	4602	1.020
2	4535	4620	1.019
3	4559	4304	0.944
4	4583	4396	0.959
5	4606	4798	1.042
6	4630	4804	1.038
7	4654	4602	0.989
8	4678	4630	0.990

The data shown in figure (3.20), shows a clear season which is four periods long. The eight periods of data used to fined initial values give two complete cycles, so the seasonal index for each period in a cycle can be found by averaging values in the two cycles see Appendix B.

Figure (3.20) Models for Seasonality and Trend for worked example (6)



There are three main problems with this approach to forecasting:

1. Firstly, there is the amount of computation, but this can easily be overcome with a specialised computer program.
2. Secondly, there is the need to initialise variables. As exponential smoothing reacts to errors, the initial values are not so important, provided the process is tuned over a suitable period.
3. Thirdly, there is the selection of smoothing constants, sometimes values for α are arbitrarily set around 0.15, but these forecasts tend to be sensitive to the values given to smoothing constants. It is worthwhile putting some effort into their selection. The best way of doing this is to have trial runs using historic data to compare errors with various values.

Chapter Four:
Discussion, Conclusion & Recommendations

4.1 Discussions:

1. From figures [2.10-2.14] show that the APC department can be arranged in there compliance with safety meeting as follows:
   a. Safety and environmental departments
   b. Production departments
   c. Trucking departments
   d. Procurements and studies departments
   e. Expansions departments.
2. By applying the motion study in Carnalities up area there is several useless movements, so these useless movements should be eliminated in the work place; definite task should be given to the workers with the knowledge how to get the task or job done. Frank [2], who was manager of the machine shop of the Midvale Steel Company, agreed that many of the men were inefficient from lack of understanding of their craft. He found that the planning of the work poor, leading to much waste of time and effort.
3. For the Activities planning chapter three taking three study cases:
   i. Case study No1 finding that:
      a. The project duration = 186 day.
      b. The critical path is [A-B-F-G-M-D-O], See Fig. (3.7) & (3.8).
   ii. Case study No.2 we find:
      a. The overall activity duration = 43day
      b. There are 2 critical paths:-
         CP1 [A-D-F-H-K-M-N] & CP2 [A-D-F-G-M-N]
      c. For the program evaluation & review techniques from inference about the activities likelihood finding the following:
      If time scheduled t_s equal to time expected t_e then the probability of this case = 25%.
      If time scheduled t_s less than time expected t_e then the probability of this case = 0.11%.
      If time scheduled t_s greater than time expected t_e then the probability of this case = 79, 3 %.
      Then the probability increased as we approach the time expected or exceed.
   iii. Case study No. 3 the application of time cost trade off.
   See fig.(3.10) reducing the project or activates overall duration time from 43days to 37days which is about 13.95% day, with a minimum

increase in the project direct costs from 6990JD to 7230JD about 3.32%JD.

The purpose of this calculation is to:

a. Avoid penalty b. Earn bonus of project completion c. complete the project before the scheduled time.

3. For moving average:

A large value of N takes the average of many observations and the forecast is unresponsive. The forecast will smooth our random variations, but will be slow to follow genuine changes in demand.

A small value of N gives a responsive forecast which quickly follows genuine changes in demand, but may be too sensitive to random fluctuations.

Fig.(3.15) shows how the three day moving average is most responsive to change and the six day moving average is the least responsive.

A particularly useful property of moving average is the way they smooth the out demands which have strong seasonal variations. If N is chosen to equal the number of periods in a season, a moving average will completely depersonalise data.

4. For Fig.(3.20) Models for Seasonality and Trend for worked example: There are main problems with this approach to forecasting.

i. Firstly, there is the amount of computation, but this can easily be overcome with a specialised computer program.

ii. Secondly, there is the need to initialise variables. As exponential smoothing reacts to errors, the initial values are not so important, provided the process is tuned over a suitable period.

4.2 Conclusions:

1. For APC safety the annual accident frequency rate (AFR) LTA's per 200,000Man Hour Worked, the Annual Accident Severity Rate Variation (ASR) & the Accident Frequency and Severity Indicator(FSI) all of them decreased with time and the relation between them and time not linear see figures (2.7, 2.8 & 2.9.
2. The human resources management: The design of formal system in an organization to ensure an effective and efficient use of human talent to accomplish organizational goal.
3. The people employed by an organization are a resource, which is a least as important as financial and material resources.
4. Motion study can be applied everywhere, in this project its applied only in the carnality up area so general modification assumed to reduce the vertical movement and to get more relaxation less fatigue. It can reduce the time and distance and used to modify the process in much comfortable and productive way for each movement.
   Calculations show that:
   The save distance % = 24.58 %
   The save time % = 17.3%
5. For machine interference of 12 machines it was found that:-
   ∑ Interference = (358574091 / 244140625)
   = 1.4687.
   The average interference per machine = 1.4687 / 12.
   = 12.239 %.
   The average servicing time = 20 – 12.24.
   = 7.761%.
6. Forecasting show that: Using simple averages to forecast demand is easy and can give good results when demand is constant (or at least relatively stable) unfortunately, it does not work will if the demand pattern is changes.
7. There is the selection of smoothing constants, sometimes values for α are arbitrarily set around 0.15, but these forecasts tend to be sensitive to the values given to smoothing constants. It is worthwhile putting some effort into their selection. the best way of doing this is to have trial runs using historic data to compare errors with various values of α.
8. Nothing remains static for long; personnel grow older, products change, or are replaced, new technology is introduced, therefore training and learning should continue to be available, and to be encouraged after the on the-job training has been successfully achieved until the new employee is performing his or her designated duties to the standard required.

4.3 Recommendations:

1. In future to apply motion study in all potash departments to take the advantage of reducing time and distance and to modify the process in much comfortable and productive way for each movement in each departments.
2. In future to study the conditions of work tension such as different type of sounds and vibration caused by machine (rotating parts, high speed , whiling of hammers) in order to prevent the fatigue which reduce the power of workers, reduction of production and affecting adversely the psychology of the worker.
3. For future to apply forecasting and estimating in the manpower planning in fact the future demand for labour by an organization, and with laying down policies and plans to ensure that, as far as is possible and feasible, the correct number of each grade of personnel is available and trained when needed.

Nomenclature

Symbol	Meaning
abst.	abstract
ann.	annals, annual
aq	aqua, water
Av*	Average
AFR	Annual accident frequency rate
AOA	Activity on arrow
AON	Activity on node
APC	Arab Potash Company
ASR	Annual severity rate
b.p.	boiling point
Conc.*	Concentration
CPUS	Central processing units
EU	European union
FSI	Accident frequency and severity indicator
HR	Human resources
HRM	Human resources management
ID	Industrial revolution
IE	Industrial engineering
IT	Information technology
OO	Object oriented
OOS	Object oriented simulation
PERT	Program evaluation and review technique
Vol	Volume
yr	year

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Appendixes

Appendix A

(A1) Procedure for motion study:

Motion study can be performed in the following steps:

Step I

Break up the operation of the job. Make a detailed list of all operations in the present method of manufacturing job. All the material handling, machine work, and hand work are also include in this detail .

Step II

Question each detail of the job. Following questions should be asked on himself by the motion study engineer about the way in which these operation are to be performed, and about the tools and equipments needed. the procedure of this questioning is known as the "Critical Examination". Questions are asked on the following five points.

i. Purpose. what is the purpose of this operation ? does this fulfil the requirements? And weather this can be eliminated?

ii, Place. Where is the best place to do this operation?

iii. sequence . what is the best time to do this operation and weather it can be done at the same time as before or at any other better time? When will it be more suitable and economical?

iv. person. who will do this operation? Who can do it in a better way?

v. Means. how this operation can be performed, i.e. ., which machines and tools are to be used? Can we make the work more easier to do and safer for both worker and equipment.

Step III

Develop a new method . after considering the a above questions a new better method is developed . apart from the above considerations before finalising the new method the following facts should also be thought over during the motion study.

Elimination:

Every operation or detailed of the job should be thought that weather it can be eliminated without any harm.

Combine:

In this aspect, it is also to be observed that weather two or more operations can be combined without any adverse effect to save operation time.

Rearrangement:

If rearrangement in the sequence of operations help in simplification or in any other aspect than it should be done.

Simplification:

In simplification, it is found that if the operation is possible with any other easy , safe and economical method that should be adopted.

Step IV

Maintaining new method . once a method is installed, it should be maintained in its specified form, and is not allowed to slip back to old form or introduction of any other unauthorised changes. For some time close contacts must be maintained with the progress of the job until it runs satisfactorily.

Step V

Maintaining new method . once a method is installed, it should be maintained in its specified form, and is not allowed to slip back to old form. For proper maintenance following steps are advised :

i. copies of job instruction sheets should be distributed to all concern. These sheets must supply the details for setting up the job and proper operation.

ii. routine checks are necessary to compare what is actually being done against the job instructions for sheets?.

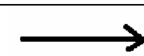
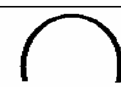
iii. selection and training of persons must be done according to the job specifications for this new method.

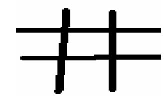
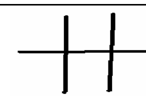
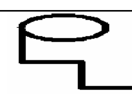
(A2) **Therbligs:**

Frank Gilberth developed a set of 17 elementary motions commonly found in manual operations and called them "therbligs" reverse spelling of his name. we knew that motion study is used for deciding the best way of doing work for which present and proposed methods are observed by experts by recording in charts. For the purpose of recording the motions he split up different motions of process into 17 fundamental elements made by various members of human body and each event was allotted a symbol and letter abbreviation. These symbols and abbreviations are used for preparing motion study charts.

Table showing 17 therbligs with their exploitation is given below.

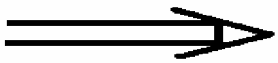
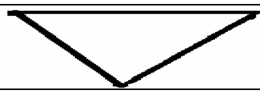
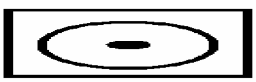
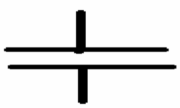
The seventeen Therbligs Table(A.1)

SI No.	Therblig	Explanation	Abbreviation	Symbol
1	Search	Attempt to locate an object	S	
2	Hold	Keep an object stationary	H	
3	Select	Choose one object from among a group	SE	
4	Grasp	Gain control or a hold on an object	G	
5	Released loaded	Relinquish hold	RL	

6	Transport loaded	Move object with body number	TL	
7	Transport empty	Re-search for an object	TE	
8	Position	Orient an object for use at its present	P	
9	Assemble	Put two or more parts together	A	
10	Prepositio n	Orient an object for use at some latter time and usually In a different location	PP	
11	Disassemb le	Separate two or more parts	DA	
12	Use	Apply object or tool	U	
13	Inspect	Examine object	I	
14	Avoidable delay	A delay which operator could prevent	AD	
15	Unavoida ble delay	A delay which operator could not prevent	UD	
16	Rest to over come fatigue	An attempt to recover from physical or mental work	R	
17	Plan	Mentally chart for future action	PN	

The symbols developed by Gilbreth are much in number and mostly all are not used in motion study. Therefore, motions were further reduced and now-a-days motions and symbols, which are commonly used are shown in the following table(A2)

Present symbols of motion study(process chart symbols) Table B (A2):

Symbol	Motion	Explanation
	Operation	Any operation for making altering or changing the job is said to be operation
	Inspection	Checking of the quality, correctness and verification is said to be the motions of inspection.
	Transport	Movement or travel of the job or any object.
	Delay	Any type of delay, i.e. breakdown, interference or time required for some adjustment.
	Storage	Keeping, holding and storing the job and other things.
	Operation and inspection	This several time occurs when operation and inspection are combined e.g., setting of tool.
	Change point	These are used before beginning any process or operation and ending or changing the study of process to another process

Appendix B

(B1)Exponential smoothing Calculating procedures for worked example (5):

Exponential smoothing is an updating process, so we must start with initial values. We will use the first two thirds of the data to fined these initial values and then do some fine tuning over the last third.
We will take the first eight values we can draw a liner regression line through them, and the usual calculations give the values of a and b.
From fig.(3.19) getting.
a = 4486.9
b = 23.905
from table (3.21) The eight periods of data used to fined initial values give two complete cycles, so the seasonal index for each period in a cycle can be found by averaging values in the two cycles.
For the first period in cycle, I (1) = (1.02 + 1.042) / 2
I (1) = 1.031
For the second period in cycle, I(2) = (1.019 +1.038) / 2
I(2) = 1.0285
For the third period in cycle, I (3) = (0.944 + 0.989) / 2
I (3) = 0.9665
For the fourth period in cycle, I (4) = (0.959 + 0.99) / 2
I (4)= 0.9745
The initial value for the trend is T (8), which is the value of b in the in the regression equation (b = 23.905)
The initial underlying value is the depersonalised value at period 8, U (8), which is 4486.9 + 8 * 23.905 =4678.
The only other value we need is a smoothing constant, α, and will be set this to 0.2.
Having found initial values, the next stage is to tune these over the last third of the data. We know that :
F (t + 1) = [underlying value + adjustment for trend] * seasonal index.
Substituting the initial values of U (8) = 4678., T (8) = 23.905 and I (1) = 1.031.
F (9) = [U (8) + T (8)] * I (1)
= [(4678 + 23.905)] * 1.031
= 4847.66
F (9) = 4847.66
This is compared with the actual demand of (4941).
The forecast for period 10 can be found by updating values using the procedure described above.

1. Deseasonalise the latest demand and use exponential smoothing to find the smoothed underlying value.
The latest underlying value is U(8) = 4678 , but the trend, T(8), has to be added to give the underlying value for the next period

(4678 + 23.905) = 4702.

The latest demand is D(9) = 4941. and the seasonal index for the first period of the cycle is I(1) = 1.03., so the latest depersonalised demand is 4941/ 1.03 = 4797.
Exponential smoothing is used to give the smoothed underlying value .

$$U(9) = \alpha * [D(9)/ I(1)] + (1-\alpha)*[U(8) + T(8)]$$
$$= 0.2*4797 + 0.8 *4702$$
$$= 4721.$$

In general this calculation is :

$$U(t) = \alpha* [D(t) / I(n)] + (1-\alpha) [U(t-1) +T(t-1)]$$

2. Use the exponential smoothing on the trend to give a smoothed a adjustment for trend.
The latest value for trend is the difference between the latest two underlying values.
These are U (8) = 4678 and U(9) = 4721, so the latest trend is (4721 – 4678 = 43).
The latest value for trend was T(8) = 23.905, so smoothed value is found using exponential smoothing :

$$T(9) = \alpha * [U(9) - U(8)] + (1-\alpha) * T(8).$$
$$= 0.2 * 43 + 0.8 * 23.905$$
$$= 27.724$$

In general this calculation is :

$$T(t) = \alpha *[U(t) - U(t-1)] + (1-\alpha) * T(t-1)$$

3.Use exponential smoothing on the seasonal index to find the smoothed index for the period.
The latest figure for the underlying value is U (9) = 4721.
The latest actual demand for period 9 is 4941, so the latest seasonal index for the first period in the cycle is 4941/ 4721= 1.047.
The last value was 1.031, so a smoothed seasonal index is calculated using exponential smoothing :

$$I(1) = \alpha * [D(9) / U(9)] + (1-\alpha) * \text{last value for } I(1)$$
$$= 0.2 * 1.047 + 0.8 * 1.031$$
$$= 1.0342$$

In general this calculation is :

$$I(n) = \alpha * [D(t) /U(t)] +(1-\alpha) * I'(n).$$

Where I′ (n) is the previous value of the seasonal index.
4. Add the underlying value to the trend adjustment and multiply by the seasonal index to give the forecast.

The next forecast is for period 10 which is the second period in the cycle and the latest value for I (2)must be used .

F(t+ 1) = [underlying value + adjustment for trend] * seasonal index

= [U (t) + T (T)]* I (n)

F(10) = [U (9) + T (9)]* I (2)

= [4721 + 27.724]* 1.0285

F (10) = 4884.

This compares with the actual demand of 4896.

This tuning procedure can be repeated as follows:

1.Latest figure for depersonalised , underlying value:

U (t) = α* [D(t) / I (n)] + (1- α)* [U(t-1) +T (t-1)].

U(10) = α* [D(10) / I (2)] + (1- α)* [U(9) +T (9)].

= 0.2 *[4896 / 1.0285] + 0.8* [4721+ 27.724]

U(10) = 4751

2. Latest figure for trend:

T(t) = α *[U (t) – U(t- 1)] + (1 – α) * T (t-1).

T(10) = α *[U (10) – U(9)] + (1 – α) * T (9).

= 0.2 * [4751 – 4721] + 0.8 * 27.724.

T(10) = 28.179

3. Latest figure for seasonal index for the second period of the cycle :

I(n) = α * [D(t) /U(t)] +(1- α) * I′ (n) .

I(2) = α * [D(10) /U(10)] +(1- α) * I′ (2) .

= 0.2 * [4896 / 4751] + 0.8 * 1.0285

I (2) = 1.0289.

4.Next forecast :

F(t + 1) = [U(t) + T (t)] * I (n)

F (11) = [U(10) + T (10)]* I (3)

= [4751 +28.179] * 0.9665.

F(11) = 4619.

We continue this updating for along as there are demand figures.

U (11) = 0.2 * [4664/ 0.9665]+ 0.8 *[4751+ 28.179]=

U (11) = 4788.

T (11) = 0.2 * [4788 – 4751] + 0.8 * 28.179.

T (11) = 29.943.

I (3) = 0.2 * [4664/ 4788]+ 0.8 *0.9665.

I (3) = 0.968.

F (12) = [4788 + 29.943]* 0.968

F (12) = 4663.9.

U (12) = 0.2 * [4736/0.9745] + 0.8 * [4788+29.943].

U (12) = 4826.

T (12) = 0.2* [4826- 4788] + 0.8 * 29.943.

T (12) = 31.55.

This finish the fine tuning of the variables , as there is no more historic data forecasts can now be found for any period in the future.

F (13) = [U(12) + T(12)] *I (1).
F (13) = [4826 + 31.55] * 1.031.
F (13) = 5008.
F(14) = [U(12) + 2* T (12)] * I(2)
F(14) = [4862+ 2 * 31.55] * 1.0285.
F (14) = 5065.5
F(15) =[U (12) + 3* T (12)]*I(3).
F (15) = [4862+ 3* 31.55] * 0.9665.
F(15) = 4791.
F(16) = [U(13) + 4* T (12)]* I (4).
F(16) = [4862+ 4 * 31.55] * 0.9745.
F(16) = 4861.
F(17) = 5175.

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